

AREA 4, CONNECTICUT RIVER TO HAMMONASSET RIVER,
CONN., BEACH EROSION CONTROL STUDY

LETTER

FROM

THE SECRETARY OF THE ARMY

TRANSMITTING

A LETTER FROM THE CHIEF OF ENGINEERS, UNITED STATES ARMY, DATED APRIL 10, 1952, SUBMITTING A REPORT, TOGETHER WITH ACCOMPANYING PAPERS AND ILLUSTRATIONS, ON A COOPERATIVE BEACH EROSION CONTROL STUDY OF THE SHORE LINE OF THE STATE OF CONNECTICUT, AREA 4, CONNECTICUT RIVER TO HAMMONASSET RIVER, PREPARED UNDER THE PROVISIONS OF SECTION 2 OF THE RIVER AND HARBOR ACT APPROVED ON JULY 3, 1930, AS AMENDED AND SUPPLEMENTED

JUNE 19, 1952.—Referred to the Committee on Public Works, and ordered to be printed, with illustrations

DEPARTMENT OF THE ARMY,
Washington 25, D. C., June 12, 1952.

THE SPEAKER OF THE HOUSE OF REPRESENTATIVES.

DEAR MR. SPEAKER: I am transmitting herewith a report, dated April 10, 1952, from the Chief of Engineers, United States Army, together with accompanying papers and illustrations, on a cooperative beach erosion control study of the shore line of the State of Connecticut, area 4, Connecticut River to Hammonasset River, prepared under the provisions of section 2 of the River and Harbor Act approved on July 3, 1930, as amended and supplemented.

A copy of the letter containing the views of the Flood Control and Water Policy Commission, State of Connecticut, is enclosed.

The Bureau of the Budget advises that, while there is no objection to the presentation of the report for the consideration of Congress,

authorization of the projects, which the Chief of Engineers considers inadvisable for the United States to adopt at this time, would not be in accord with the program of the President.

Sincerely yours,

FRANK PACE, Jr.,
Secretary of the Army.

LETTER FROM CHIEF, RESOURCES AND CIVIL WORKS DIVISION,
BUREAU OF THE BUDGET

EXECUTIVE OFFICE OF THE PRESIDENT,
BUREAU OF THE BUDGET,
Washington 25, D. C., May 15, 1952.

The honorable the SECRETARY OF THE ARMY

(Through the Budget Officer for the Secretary of the Army).

MY DEAR MR. SECRETARY: This will acknowledge receipt of your letter, dated April 21, 1952, submitting the proposed report of the Chief of Engineers on a cooperative beach erosion control study of the shore line of the State of Connecticut, area 4, Connecticut River to Hammonasset River, prepared under the provisions of section 2 of the River and Harbor Act approved July 3, 1930, as amended and supplemented.

I am authorized by the Director of the Bureau of the Budget to advise you that, while there would be no objection to the presentation of the report for the consideration of Congress, authorization of the projects, which the Chief of Engineers considers inadvisable for the United States to adopt at this time, would not be in accord with the program of the President.

Sincerely yours,

CARL H. SCHWARTZ, Jr.,
Chief, Resources and Civil Works Division.

COMMENTS OF THE STATE OF CONNECTICUT

STATE OF CONNECTICUT,
STATE WATER COMMISSION,
Hartford 15, March 31, 1952.

DEPARTMENT OF THE ARMY,
Office of the Chief of Engineers,
Washington, D. C.

GENTLEMEN: Reference is made to your letter of January 18, 1952, requesting comments on Beach Erosion Control Report, area IV, State of Connecticut, Connecticut River to Hammonasset River.

This commission has worked closely with the New England division engineer's office during preparation of this report and has periodically approved various sections as they were completed. We believe this report best satisfies the interests of all parties concerned.

It should be noted that some time has elapsed since collection of some of the basic data and since we reviewed some of the sections of this report. During that period a serious storm occurred in the area

and has made changes in its physical features. In our opinion none of these physical changes substantially affect the accuracy of the report or its conclusions and recommendations.

We approve the conclusion and recommendations for area IV.

Sincerely yours,

RICHARD MARTIN, *Director.*

REPORT OF THE CHIEF OF ENGINEERS, UNITED STATES ARMY

DEPARTMENT OF THE ARMY,
OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., April 10, 1952.

Subject: Cooperative beach erosion control study of State of Connecticut (area 4, Connecticut River to Hammonasset River).

To: The Secretary of the Army.

1. I submit for transmission to Congress a report with accompanying papers on a beach erosion control study of that part of the shore of Connecticut comprising the section lying between Connecticut and Hammonasset Rivers made by the Corps of Engineers in cooperation with the State of Connecticut under the provisions of section 2 of the River and Harbor Act approved July 3, 1930, as amended and supplemented.

2. After full consideration of the report of the division engineer, the Beach Erosion Board concurs in his conclusion that the best plans of protection and improvement comprise a riprap wall at the Borough of Fenwick, direct placement of sand fill and construction of one groin at Plum Bank Beach, direct placement of sand fill at Great Hammock, Saybrook Manor, Chalker, Chapman, and West Beaches, and construction of one groin at Grove Beach. The Board also concludes that the public ownership and interest in the projects is insufficient to warrant Federal aid under the policy established by Public Law 727, Seventy-ninth Congress. The Board recommends that local interests consider adoption of projects for protection and improvement of these beaches at local expense, making independent evaluations of prospective benefits to determine the justification of the projects. As existing Federal law does not include a policy of Federal aid in the cost of protecting privately owned shores, no Federal participation in the cost of work is recommended. Accordingly, the Beach Erosion Board recommends that no projects be adopted by the United States at this time for protection and improvement of the shores within the areas studied.

3. The Beach Erosion Board states its opinion, as required by law, as follows:

"(a) It is inadvisable for the United States to adopt projects authorizing Federal participation in the cost of protecting and improving the shores within the area studied;

"(b) The public interest involved in the proposed measures for these shores is small; and

"(c) No share of the expense should be borne by the United States."

4. After due consideration of these reports, I concur in the views and recommendations of the Beach Erosion Board. Because of their

general interest to the public and their value to local authorities, I recommend that these reports with selected illustrations, be published.

LEWIS A. PICK,
*Lieutenant General,
Chief of Engineers.*

REPORT OF THE BEACH EROSION BOARD

BEACH EROSION BOARD,
CORPS OF ENGINEERS,
Washington 16, D. C., December 28, 1951.

Subject: Beach erosion control report on cooperative study of Connecticut (area 4, Connecticut River to Hammonasset River).

To: The Chief of Engineers, United States Army, Washington 25, D. C.

1. This report is on a study of beach erosion made in cooperation with the State of Connecticut under authority of section 2 of the River and Harbor Act approved July 3, 1930, as amended and supplemented. The purpose of the investigation was to determine the most suitable methods of stabilizing and improving the shore line.

2. Area 4 of the State of Connecticut study comprises the shore of Long Island Sound between the mouths of Connecticut River and Hammonasset River. It includes the shores of the towns of Old Saybrook, Westbrook, and Clinton, a total length of about 12.5 miles. This shore area is about 30 miles east of New Haven, Conn., and about 100 miles east of New York City. It is extensively developed as a resort and residential area, with improvements ranging from cottages to small estates. The permanent population of the 3 towns is about 6,500; the summer population is more than 3 times as great. A number of small town-owned beaches are included in the area.

3. Long Island Sound is a tidal arm of the Atlantic Ocean. Tides are semidiurnal, the mean range increasing gradually from 3.5 feet at Saybrook to 4.7 feet at Clinton. Spring ranges are respectively 4.2 and 5.5 feet at these locations. Maximum tide of record at Saybrook was 9.9 feet above mean high water. Tides 3 feet or more above mean high water occur about once a year. With a tidal stage of 3 feet above mean high water, the maximum height of breakers landward of the low-water line is about 5 feet at the east end of the study area and 6 feet at the west end. Larger waves can reach the shore only during infrequent higher tides.

4. Due to the limited size of Long Island Sound, local storms are the sole cause of important wave action. Ordinary short storm waves cause littoral movement and offshore loss of beach material. Absence of swells probably precludes the possibility of return of material from offshore by wave action. The greater fetch and wind movement from the west and southwest account for the general predominance of eastward and northward littoral drift depending on shore alinement. Waves caused by easterly storm winds cause reversals of drift direction. Where sections of the shore are protected by islands or structures from waves from the west, westward littoral drift is predominant.

5. The study area is characterized by headlands of unconsolidated glacial material with some rock outcrops, between which wave-built bars have been formed and the landward areas generally have filled

and become marshy. The headlands formerly supplied ample material to the intervening beaches, but the headlands are now generally protected by sea walls and revetments. The supply of material is thus reduced or eliminated and consequently the beaches have slowly deteriorated. Groins have been found to be capable of causing minor accretion areas and stabilizing a narrow band along the upper portion of the beach, but the natural supply of material is insufficient for the formation of adequate protective beaches. The building and maintenance of adequate beaches may be accomplished by artificial placement of sand. The prospective low rates of loss of beach material, based on past experience of shore line recession, are insufficient to warrant the construction of groins, except where necessary to prevent the shoaling or closing of inlets or drainage channels.

6. The division engineer has considered the desires of the cooperating agency, has determined the sources and movement of beach material, the changes in the shore line and offshore bottom, the effects of winds, storms, and of existing structures, has developed plans for protecting and improving the shores of the area, and has made economic analyses of proposed protective and improvement measures. He concludes that the best plans for the protection and improvement of beaches within the study area are as follows:

(a) *Borough of Fenwick (west part)*.—Construction of a dumped riprap wall along the high-water shore line;

(b) *Plum Bank Beach*.—Direct placement of a protective sand beach in front of the sea walls and cottages, and construction of an impermeable groin at the north limit of the fill;

(c) *Great Hammock Beach*.—Direct placement of a protective sand beach or dune in front of the cottage development;

(d) *Saybrook Manor, Chalker Beach, and Chapman Beach*.—Direct placement of a protective sand beach in front of the cottage or residential developments;

(e) *West Beach*.—Direct placement of a protective sand beach in front of the sea wall along the west end of the public beach and in front of the cottage development west of and adjacent to the sea wall;

(f) *Grove Beach*.—Construction of an impermeable groin at the east end of the beach.

7. The division engineer finds that the proposed plans for Plum Bank Beach, Great Hammock Beach, Saybrook Manor, Chalker Beach, and Grove Beach are justified by evaluated benefits, but that the public ownership of the shore is insufficient to warrant adoption of Federal projects for protecting any of these areas. He recommends that local interests adopt projects for the protection and improvement of these beaches, in accordance with the plans outlined in the preceding paragraph.

8. Local interests were advised of the findings and recommendations of the division engineer and invited to present additional information for the consideration of the Beach Erosion Board. Careful consideration has been given to all communications received.

VIEWS AND RECOMMENDATIONS OF THE BEACH EROSION BOARD

9. The Board has carefully considered the report of the division engineer. It concurs generally in his views and recommendations subject to the comments contained in the following paragraph.

10. The Board concurs in the methods of protection and improvement proposed by the division engineer and that projects for Plum Bank, Great Hammock, Saybrook Manor, Chalker, and Grove Beaches appear to be justified by evaluated benefits. The Board also believes that the public ownership and interest in the projects are insufficient to warrant Federal aid under the policy established by Public Law 727, Seventy-ninth Congress. The Board recommends that local authorities consider adoption of projects for protection and improvement of these beaches at local expense, substantially in accordance with the plans proposed by the division engineer. The Board considers it advisable, however, for local interests to make independent evaluations of prospective benefits from these projects in determining justification for their construction at local expense.

11. In accordance with existing statutory requirements the Board states its opinion that—

(a) It is inadvisable for the United States to adopt projects authorizing Federal participation in the cost of protecting and improving the shores within the area studied;

(b) The public interest involved in the proposed measures for these shores is small; and

(c) No share of the expense should be borne by the United States.

12. The Board recommends that no projects be adopted by the United States at this time authorizing Federal participation in the cost of measures for the protection and improvement of the shores within the area covered by this report.

For the Board:

E. E. GESLER,
Colonel, Corps of Engineers,
President.

At the time of adoption of this report the members of the Beach Erosion Board were Col. E. E. Gesler, president; Dean Thorndike Saville, State of New York; Dean Morrough P. O'Brien, State of California; Dr. Lorenz G. Straub, State of Minnesota; Col. Wendell P. Trower, Corps of Engineers; Col. Donald S. Burns, Corps of Engineers; Col. Richard W. Pearson, Corps of Engineers.

REPORT OF THE DIVISION ENGINEER

SYLLABUS

This report, the fourth of a series to cover the entire coast of Connecticut, includes study of the shore line of the towns of Old Saybrook, Westbrook, and Clinton lying between the Connecticut River and Hammonasset River. The purpose of the study is to determine the most suitable methods of stabilizing and improving the shore line.

The division engineer finds that the entire area constitutes a resort development and that major extents of the shore have suffered from erosion, resulting in the loss of sand beaches and shore property. The Division Engineer also finds that the most suitable method of stabilizing and improving the shore consists of the restoration of beach losses by hydraulic dredging from offshore areas and, in a few instances, the construction of impermeable groins.

The division engineer recommends that local interests consider adoption of projects for protection and improvement of the following shores:

- (a) Plum Bank Beach, Old Saybrook.
- (b) Great Hammock Beach, Old Saybrook.
- (c) Saybrook Manor, Old Saybrook.
- (d) Chalker Beach, Old Saybrook.
- (e) Grove Beach, Westbrook.

There is insufficient public ownership or public interest involved in protection and improvement of any of the shores considered to justify adoption of a Federal project authorizing contribution of Federal funds for the construction of protective works.

BEACH EROSION CONTROL REPORT ON COOPERATIVE STUDY OF CONNECTICUT, AREA 4, CONNECTICUT RIVER TO HAMMONASSET RIVER

I. GENERAL

1. *Authority.*—This report was prepared by the Corps of Engineers, United States Army, in cooperation with the Connecticut State Flood Control and Water Policy Commission under authority of section 2 of the River and Harbor Act approved July 3, 1930, as amended and supplemented. The basic agreement for the study of the entire Connecticut shore line was approved by the Chief of Engineers on August 28, 1947, and the detailed program for this area on September 9, 1948.

2. *Purpose.*—The purpose of the study is to determine (1) the most suitable methods of stabilizing and improving the shore line between the Connecticut River and the Hammonasset River; (2) which sections of the shore are desirable locations for beach improvements and the most effective measures for accomplishing the improvements; and (3) the economic justification of protective and improvement measures.

3. *Prior reports.*—(a) *The physical history of the Connecticut shore line.*—Bulletin No. 46 of the State Geological and Natural History Survey of Connecticut published in 1929 is a paper by Henry Staats Sharp, A. M., titled, "The Physical History of the Connecticut Shore Line." This paper describes the geological history of Connecticut and the various topographical features of the shore line. The geological history contained in appendix B is based principally upon this report.

(b) *Effect of Federal structures on adjacent shore lines.*—A report, Effect of Federal Structures on Adjacent Shore Lines, dated July 11, 1938, and a supplement thereto dated February 3, 1939, were submitted to the Shore Protection Board describing conditions before and after construction of two jetties at the mouth of the Connecticut River and three breakwaters at Duck Island Harbor. Date of authorization and construction, purpose and effect of these structures are given in appendix G.¹

4. *Location.*—The portion of the Connecticut shore considered in this report is an extent of about 12.5 miles located between the Connecticut River and the Hammonasset River. The area extends from the first point of land north of Lynde Point on the west bank of the Connecticut River to a point on the east side of Clinton Harbor opposite Cedar Island. It contains the shore of the towns of Old Saybrook, Westbrook, and Clinton, approximately 5.6, 4.2, and 2.7 miles in length, respectively. This area lies about 20 to 30 miles west of New London, 25 to 35 miles east of New Haven, and 100 to 110 miles east of New York City. Access to the shore is provided by a network of town roads, United States Route 1 and State Highways 154 and 145 which very closely parallel Long Island Sound. The New York, New Haven & Hartford Railroad also runs parallel to the shore about $\frac{1}{2}$ to 2 miles inland.

¹ Not printed.

5. *Population.*—The population in the area is largely seasonal. The permanent population of Old Saybrook is 2,500 and the summer population about 10,000. Westbrook has a permanent population of 1,500 which increases to 6,000 during the summer. Clinton has a year-round population of 2,500 and a summer population of 5,000.

6. *Description.*—The shore line of the study area is a shore line of submergence. Headlands are composed principally of unconsolidated glacial till. Old Kelsey Point is a projection of bedrock. Past erosion of headlands has supplied material to form existing beaches, largely in the form of spits or barrier bars. Areas behind these barrier beaches have filled and become marshy. Detailed descriptions of specific beach areas are included in the discussion of methods of protection in a later section.

II. FACTORS AFFECTING SOLUTION OF PROBLEMS

7. *Source of supply.*—Headlands composed of unconsolidated glacial till were formerly the principal source of supply of beach material. Protective measures have practically eliminated this source.

8. *Rates of supply and loss.*—The rate of loss of beach material in general slightly exceeds the rate of supply. Over the period of record, a large part of the shore line has receded at rates of 1 to 3 feet per year. Minor accretion areas have resulted from structures or natural projections from the shore. Detailed descriptions of shore line and offshore depth changes at specific beaches are included in appendix E.¹

9. *Mechanism of loss.*—The loss of beach material is caused by wave action. Although the general features of the problem are essentially the same, detailed features vary throughout the area. The waves are short waves caused by local winds. Due to the prevailing winds from the west and southwest (about 40 percent of the time), blowing over a maximum fetch of about 80 miles, prevailing waves approach from those directions. Prevailing storm waves also approach from the west but a substantial percentage of storm waves are generated by east winds. Tides are semidiurnal. The mean range varies from 3.5 feet at Saybrook Jetty to 4.7 feet at Clinton Harbor. The maximum tide of record at Saybrook was 13.4 feet above mean low water. Tides in excess of the mean height of high water occur as follows: 3 feet in excess about once a year; 2 feet in excess about 5 times a year, and 1 foot in excess about 98 times a year. The maximum height of breakers inside the low water line with tides 3 feet in excess of the mean height of high water is approximately 5 feet at the east end of the study area and approximately 6 feet at the west end of the study area, but during infrequent higher tides larger waves can reach the shore. The movement of material by wave action is diverse in character. Ordinary short storm waves cause littoral drift and offshore loss of beach material. Absence of swells probably precludes the possibility of return of material from offshore by wave action. Except where the shore is protected by islands or structures, the predominant direction of littoral drift is generally eastward or northward, depending on the shore alinement. Waves generated by easterly storm winds cause a reversal of the predominant eastward drift.

10. *Methods of modifying rates of supply and loss.*—In general, the rate of supply of beach material cannot be increased except by artifi-

¹ Not printed.

cially placing material directly on the beach or in stockpiles to be distributed by wave action. Sources of sand have been determined to exist within practicable distance for hydraulic dredging and pumping to shore. Groins which have been built in the area have been found to be capable of stabilizing a narrow band along the upper portion of the beach, indicating that some littoral drift exists at these locations. In some instances, small accretion areas have resulted from groin construction. Loss of land has been prevented, except during the most severe storms and hurricanes, by armoring the shore against wave attack by revetments and sea walls in those areas where supply of material has been inadequate to maintain a protective beach. Sea walls and revetments have not contributed to the creation or maintenance of protective beaches. Such structures have actually reduced the supply of material available for beaches. Other methods of modifying rates of supply and loss, such as offshore breakwaters, are not considered applicable in this area.

11. *Design criteria*.—Proposed protective measures are designed to provide protection against ordinary conditions of comparatively frequent occurrence (at least once a year). They are not expected to provide protection to water-front structures in the event of hurricanes or exceptional storms of infrequent occurrence although even under these conditions some protection will be afforded. Specific design criteria used for protective works in this study area are as follows:

(a) *Design tide*.—The maximum elevation of tides which occur at least once a year. Tide records at New London and Saybrook indicate that this elevation is 3 feet above the plane of mean high water.

(b) *Sea wall elevations*.—Not less than the height of the design tide plus three-fourths the maximum height of breaking waves at the location of the proposed wall when the water elevation is at design tide level.

(c) *Groins*.—A top elevation of the inshore end of groins not less than the general height of existing berms of beaches. In this area, beach berm levels are approximately 5 feet above the plane of mean high water. A width of inner horizontal section equal to the width of berm of the anticipated beach. A slope of intermediate section not steeper than the slope of the existing bottom. A top elevation of the outer end of the groin not lower than the plane of mean low water. For riprap construction, a minimum height of groins of 3 feet. Groins to be sandtight and firmly secured to bulkheads or to high land on shore. Groins to extend out to a depth of 6 feet below mean low water if practicable. In shallow areas where such groin lengths would be excessive, the length to be determined by the width of anticipated beach or sand fill.

(d) *Sand fills*.—Berm elevations of proposed fills to equal those of existing beach berms. A minimum berm width of 25 feet. Slopes of fill of 1 on 20 to 1 on 40, generally 1 on 30.

III. PLANS OF IMPROVEMENT

12. *Borough of Fenwick (east part)*.—This portion of shore extends from a point approximately 2,200 feet west of the west Saybrook jetty to the east limit of the study area. It consists of a sand beach and dune fronting a low marshy area. The only development on the shore is a lighthouse at Lynde Point. This lighthouse is adequately pro-

tected by a sea wall. There is a row of houses extending in a south-west direction from the lighthouse. This row of houses is located about 150 to 800 feet behind the shore. In 1851, prior to the accretion resulting from construction of the jetty at the mouth of the Connecticut River, the shore was located about 75 feet from the line of these houses. Ownership of the shore rests in the Federal Government (the lighthouse reservation), the Borough of Fenwick, and private property owners. The shore is not used by the general public. The only serious erosion has occurred along the westerly 1,200 feet of this area resulting in a recession of the high-water line of approximately 300 feet since 1838. The area behind this part of the shore consists of marsh and is entirely undeveloped and in its present state is unsuitable for development. In view of the limited development of this area and the unsuitability for development of the only portion of shore which has experienced rapid erosion, no plan of improvement is considered justifiable.

13. *Borough of Fenwick (central part).*—This is a stretch of privately owned shore 2,200 feet long located between points 2,200 and 4,400 feet west of the west Saybrook jetty. The area is continuously developed for residential use. It is occupied by large, widely spaced residences. The shore is protected by sea walls fronted by groins, a solid fill pier and a small offshore breakwater. The groins and pier have stabilized the shore. The existing structures provide adequate protection against erosion. Due to lack of a source of supply, only small amounts of littoral drift material are caught by the groins. If a wider beach is desired in front of the sea walls, it is practicable to create it by the artificial placement of sand and the extension of existing groins to hold the fill in place. No additional protective works are considered necessary at this time.

14. *Borough of Fenwick (west part).*—This is an extent of shore 2,000 feet long, including the western 1,750 feet of the Borough of Fenwick and 250 feet of the adjacent Fenwood development. The area has suffered considerably from erosion which caused a recession of the shore of about 100 feet between 1883 and 1949. Short sections of the shore are protected by low walls and a timber bulkhead and a number of very short groins. The existing structures are inadequate to arrest the processes of erosion. The area is partially developed for residential use. The beach is composed of sand and gravel above high water and gravel below high water. There are four widely spaced residences located from 50 to 100 feet behind the high water line. These residences are not in any immediate danger but continuation of the erosion which has been occurring can place them in a precarious position. Approximately 491 feet of the shore consisting of three lots and three street ends belong to the Borough of Fenwick. No use is made of this property at the present time. The problem is to stop losses of public and private land and protect the private development by preventing further recession of the shore. In a preliminary plan consideration was given to construction of impermeable groins to stabilize the shore. Due to the lack of a source of supply of littoral drift material, groins cannot be expected to impound a protective beach. Their principal value would be to reduce losses of material now occurring through erosion. More positive and more economical protection against shore recession can be obtained by construction of a wall of dumped riprap at the mean high water line. In order to provide

protection against ordinary storms, such a wall should have a top elevation at least equal to the height of the design tide plus the maximum height of waves superimposed on this tide. The design tide elevation is 6.6 feet above mean low water. The height of the maximum wave above this tide level is approximately 2 feet. The height of wall considered is 9 feet above the plane of mean low water. The wall will be overtopped during infrequent storms and some water damage will probably occur, but the wall is expected to maintain the present position of the high water shore line. The plan involving construction of the riprap wall is shown on plate 15.

15. *Guardhouse Point to Cornfield Point*.—This is an extent of privately owned shore approximately 7,350 feet long located between the eastern end of an abandoned concrete sea wall fronting the Fenwood development and the tip of Cornfield Point. It includes 1,450 feet of the Fenwood development, 2,800 feet of the Knollwood development and 3,100 feet along the east side of Cornfield Point. The shore consists of shingle, cobbles, and boulders. The only sandy beach in the entire area is held artificially by a steel sheet pile groin and solid fill pier in the Knollwood section and it is used as a private bathing beach. Protection is afforded the area by an abandoned deteriorating concrete wall in front of the Fenwood section, a system of sea walls, bulkheads, and cut stone and riprap revetment along the Cornfield section and cut stone revetment along the seaward side of the shore highway paralleling the shore of Fenwood and Knollwood. Shore line comparisons indicate that there has been little change in the position of the high water line since 1851. Existing protective structures, provide adequate protection against ordinary storm conditions. Exceptional storms like the one of November 1950 can cause damage to protective structures. Some sea walls along the Cornfield section were destroyed during this storm. Losses of this nature can be reduced by revetment of the bluff above and behind the sea walls to prevent possible erosion and washing out of backfill. Further deterioration of the concrete wall fronting Fenwood could expose this area to serious erosion. Sandy bathing beaches can be created if desired by the placement of sand and the construction of groins to hold the sand in place. There are no sources of littoral drift material available to build beaches by natural processes. Maintenance of existing protective works will provide adequate protection.

16. *Cornfield Point to Plum Bank Creek (Plum Bank Beach)*.—This stretch of shore is about 4,600 feet long and consists of a protruding headland of unconsolidated glacial material and a barrier bar extending northwestward fronting an extensive marsh area. Due to its projection into Long Island Sound, Cornfield Point is exceptionally exposed to wave attack. Between 1838 and 1933 erosion caused a shore recession of 150 to 200 feet along the southerly 1,000 feet of the western side of the point. The shore of this southerly area is now protected by heavy dumped riprap, stone bank paving, heavy masonry walls and a series of groins. The finer beach material has been removed by erosion, leaving a coarse shingle, cobble, and boulder shore. There has been little change in the position of the high-water line since 1933. The coarse blanket of beach material and the existing protective structures have provided sufficient protection to make this shore fairly stable. Maintenance of these structures should protect the area sufficiently to prevent serious losses in the future. The

barrier bar extending northwestward from Cornfield Point has a narrow sandy beach in front of low concrete and masonry walls and heavy cut stone revetment. This sandy beach is protected by a series of very closely spaced groins which hold material on their south sides, forming an irregular sawtooth-shaped shore. The barrier bar is occupied by a row of cottages located behind the narrow beach. Portions of the shore are used for a public, town-owned and private, association-owned bathing beach. Due to the narrowness of the fronting beach and the low elevation of the bar, the present structures are not satisfactory for protection of the area. The plan of protection and improvement considered consists of placing a wider sand beach in front of existing walls by hydraulic dredging from offshore areas. Consideration was given in a preliminary plan to construction of a series of impermeable groins to stabilize the proposed fill. Due to the low rate of loss of beach material indicated by comparison of shore line positions over the period of record, it appears that maintenance of the sand fill by periodic replenishment of losses will be more economical than groin construction. If actual fill losses exceed estimated losses, construction of groins may be economically justified. Due to the existence of northward drift, movement of the sand fill would tend to close the mouth of Plum Bank Creek. To prevent this, a terminal groin at the north end of the fill is necessary. The plan of protection is shown on plate 16.

17. *Great Hammock Beach.*—This is an extent of privately owned shore about 2,000 feet long located between Plum Bank Creek and Oyster River. Between 1838 and 1933 erosion resulted in a shore recession of 150 to 200 feet, but shore line changes since 1933 have been small. The entire backshore consists of low-lying marshy land subject to flooding during extreme high tides. The area is not suitable for development in its present state. There is a development behind the central portion of the shore consisting of about 50 cottages. Some of these cottages are located very close to the edge of the water. Continued erosion can result in their destruction in the near future. Some protection is afforded these shore cottages by a low riprap mound which acts as a wave breaker along the edge of the water. Complete protection of the cottage development would require construction of some form of dike or wall around its perimeter. The problem created by flooding is not due to shore erosion and its solution is not regarded as being within the scope of this report. Protection of the shore fronting the cottages has been considered. The plan of protection for this area consists of placing a sand beach or dune in front of the cottage development by hydraulic dredging of offshore material. Construction of an impermeable groin at the north end of the fill to retard its erosion was considered in a preliminary plan. Since changes in the position of the shore line since 1933 have been small, it appears that maintenance of the sand fill by periodic replenishment of losses will be more economical than groin construction. The groin has, therefore, been omitted. The plan of protection is shown on plate 16.

18. *Saybrook Manor.*—The privately owned shore adjacent to and west of Oyster River known as Saybrook Manor has been subject to considerable erosion resulting in a shore recession of over 100 feet between 1838 and 1933. This erosion has continued to the present time causing a sand bar to retreat about 200 feet over the marsh along

the easterly 300 feet of the area. West of this bar for about 650 feet the shore is partially protected by low concrete and masonry walls, riprap revetment, and short riprap and timber groins. The shore fronting the walls has receded so that there is little or no beach remaining. This shore is generally sandy in composition and is used for bathing by residents. The area is occupied by a cottage development. It is related in the Physical History of the Connecticut Shoreline, published in 1929, that rapid retreat of the shore of about 100 feet in a period of 25 years left a residence on piles seaward of the high-water line. It also mentions piles observable at that time seaward of this house, denoting the former position of another house which was destroyed in a storm several years before. An illustration of the house on piles was printed in the report. The house does not exist today. The plan of protection considered consists of placement of a protective sand beach in front of the cottage development. Consideration was given in a preliminary plan to construction of an impermeable groin at the east limit of the fill to reduce losses of the fill through eastward drifting. Since losses of beach material indicated by changes in the position of the high-water shore line have been comparatively small, it is felt that periodic replenishment of fill losses will be more economical than groin construction. The plan of protection is shown on plate 16.

19. *Indiantown Harbor*.—This is a small privately developed boat harbor located between Saybrook Manor and Chapman Point. The eastern end of the area consists of a projecting point of land protected by a masonry sea wall. Two riprap breakwaters enclose an area northeast of Chapman Point. The shore within the breakwaters is protected by timber bulkheads and groins. There is no serious erosion problem within the area. Maintenance of existing structures should provide adequate protection against erosion in the future.

20. *Chalker Beach*.—This is a sandy stretch of privately owned shore 2,800 feet long located between Chapman Point and Cold Spring Brook. The westerly 1,800 feet of shore is occupied by a row of closely spaced cottages located at or very close to the high-water line. These cottages are protected by timber bulkheads, rows of piles which act as wave breakers and short timber groins. The remainder of the shore is occupied by widely spaced cottages and a summer lodge set 50 or more feet behind the high-water line. There are no protective structures along this easterly end of the beach. Due to the narrowness of the fronting beach along the westerly 1,800 feet of shore, the cottage development is subject to wave attack and consequent damage and flooding during easterly storms. Additional protection is needed for this area. There is a riprap breakwater constructed in a southeasterly direction from Chapman Point during 1929. The inshore end of this breakwater has become separated from the shore by recession of Chapman Point and the beach west of it. Stabilization of this shore may be desirable to prevent continuation of losses of beach material and eventual exposure of the development at the eastern end of the beach to wave attack. The plan of protection and improvement considered consists of direct placement of a protective sand beach in front of the cottages closely bordering the shore along the westerly portion of Chalker Beach. Consideration was given in a preliminary plan to the construction of impermeable groins at the ends of the fill and at the east end of the beach at Chapman Point to reduce losses of material.

Since the rate of loss of beach material, as indicated by changes in the position of the high-water shore line, has been small, it appears that periodic replacement of fill losses will be more economical than groin construction. The plan of protection and improvement is shown on plate 16.

21. *Chapman Beach*.—This is an extent of privately owned shore located between Cold Spring Brook and Old Kelsey Point. It consists of two compartments or pockets separated by a projecting rock outcrop. The easterly pocket is approximately 800 feet long and was formed by erosion which caused a shore recession of over 200 feet between 1838 and 1933. There was a small amount of accretion in this area between 1933 and 1949. The easterly half of this pocket beach is an undeveloped sandy barrier bar or dune fronting marsh. The westerly half is occupied by residences fronted by low masonry walls in an advanced state of deterioration. The shore material in front of the residences is gravel and sand. The plan of protection and improvement considered involves the artificial placement of sand in front of the residential development to provide a protective beach. The western compartment or section of Chapman Beach is approximately 1,100 feet long and is continuously developed for residential use. The backshore on which the residences are built is an eroding bluff which is partially protected by sea walls and timber bulkheads. The foreshore is held by a series of short groins which are holding material on their west sides, indicating the existence of easterly drift. Shore line comparisons indicate very little change in the position of the high-water line between 1838 and 1933. A small amount of shore recession occurred between 1933 and 1949, except at the west end of the beach where accretion resulted from impounding of drift by the most westerly groin. This groin intercepts material which would otherwise feed the beach further east. The existing beach is narrow. The groins have formed an irregular shore line. A more satisfactory beach can be created by direct placement of sand in front of the protecting sea walls and bulkheads. The wider beach so created would provide greater protection against wave attack and erosion for the backshore on which the residential development is located. Consideration was given in a preliminary plan to construction of an impermeable groin in each pocket at the east end of the sand fills to reduce losses of beach material. Since losses of material, as indicated by shore line changes, have been small, it will probably be more economical to replace these losses periodically than to construct groins. The plan of protection and improvement is shown on plate 16.

22. *Old Kelsey Point to Salt Works Point*.—This is an extent of privately owned shore approximately 1,800 feet long consisting of projecting headlands and ledge rock outcrops. Masonry sea walls protect the greater part of the area. The foreshore around Old Kelsey Point is coarse and eroded. There is a small coarse sand and shingle beach on the west side of the point in an indentation of the shore. This beach is about 20 feet wide above the high-water line. A pervious riprap groin has been constructed at the east limit of this pocket and a small timber groin in its center. West of this pocket, the shore consists of ledge rock outcrops to the east limit of another longer sandy pocket comprising the shore of Salt Works Bay. This pocket terminates at projecting ledge rock outcrops at Salt Works Point. The rock outcrops, coarse foreshore material, and existing

sea walls make the entire shore comparatively stable. Use of the shore is limited to area residents. The small pocket beach located immediately west of Old Kelsey Point can be improved by placement of sand fill to widen the beach. Such a sandy beach can be held by reconstruction of the existing riprap groin to make it sand tight and increase its length. No specific plan for protection of the shore is needed at the present time.

23. *Salt Works Point to Money Point.*—This is an extent of privately owned shore approximately 1,900 feet long located between Salt Works Point and a creek west of Money Point which marks the east limit of Stannard Beach. The area is continuously protected by masonry sea walls fronted by a series of timber groins and a riprap groin at Money Point. The beach in front of the sea walls is narrow and is composed of sand and large amounts of gravel. The groins and walls appear to have stabilized the shore so that there is no immediate danger of serious losses due to erosion. If desired, a minor beach improvement can be effected between Salt Works Point and Money Point by placing sand fill between existing groins. Maintenance of existing protective structures should provide adequate protection for present needs.

24. *Stannard Beach.*—This is a sandy privately owned beach about 1,900 feet long, bounded by a creek at its east end and a ledge-rock outcrop at its west end. The beach width above high water is 25 feet at the west end, increases to about 60 feet in the center, and decreases to about 15 feet at the east end. The backshore is a low-lying area occupied by a cottage development fronted by low masonry walls. The foreshore is used as a private bathing beach. Wide off-shore sand flats provide natural protection against wave attack. The beach is comparatively stable. The narrow east end of the beach is held by short timber groins. Additional width appears desirable at this end of the beach. This can be effected if desired by direct placement of sand fill in front of the walls. A beach width above the plane of mean high water of 50 feet should be sufficient for present needs. In a preliminary plan, consideration was given to construction of an impermeable groin at the east limit of the beach. Due to the natural stability of the shore, no structures are considered necessary to prevent losses of the fill. It is possible that with a wider beach littoral drift will tend to fill the creek. This may require the construction of a training wall at the west side of the creek. Maintenance of existing protective structures should provide adequate protection for the area.

25. *Little Stannard Beach.*—This is a privately owned sandy pocket beach about 700 feet long located between a ledge rock outcrop at its east end and a steel sheet pile groin at its west end. The backshore is occupied by a cottage development fronted by low masonry walls. The beach in front of the walls is generally over 50 feet wide. Off-shore sand flats provide natural protection against wave attack. The shore is in satisfactory condition. No additional protection is required.

26. *Middle Beach.*—This is a sandy shore extending about 1,500 feet westward from Little Stannard Beach. The backshore is occupied by closely spaced cottages fronted by low masonry walls. There is a short stretch of publicly owned shore at the east end of the area used as a public bathing beach. There are no public facilities at this

town beach and its use is, therefore, largely limited to nearby residents. Middle Beach is generally 40 to 50 feet wide above high water except along its easterly end in the vicinity of the public beach where the width diminishes to about 15 feet. Offshore sand flats provide natural protection against wave attack. There has been very little change in the position of the high-water line in recent years, an indication that the shore is comparatively stable. Widening of the easterly end of the beach may be desirable to provide a wider public bathing beach and to protect the area behind the beach. During the storm of November 25, 1950, the masonry sea wall along the public beach was so badly damaged that the town is considering construction of a new wall landward of the existing one. Failure of the wall was largely due to its inherent weakness. Widening of the narrow beach can best be effected by direct placement of sand so as to fill the area between existing groins. When the steel groin located at the east end of Middle Beach impounds material to the limit of its capacity, extension of the groin will probably effect further widening. Experience indicates that material is impounded by this groin at a slow rate. Maintenance of existing protective works should provide adequate protection for the area.

27. *Quotonset Beach*.—This is a privately owned sandy beach extending about 2,100 feet westward from Middle Beach. There has been very little change in the position of the high-water line since 1838. The backshore is occupied by large residences and is continuously protected by a system of low masonry walls and by riprap revetment. The width of the beach above high-water increases from 0 feet at its west end to about 50 feet at its east end. Offshore flats provide natural protection to the shore against wave attack. This stretch of shore does not have any serious erosion problem. If a wider sand beach is desired, it can be created by direct placement of sand. Care should be taken in placement of such a beach to preserve the smooth continuous curve of shore now existing so as not to create any projecting points which would be subject to more rapid erosion. The existing structures are adequate for protection of the shore under present conditions.

28. *West Beach*.—This is an extent of sandy shore about 6,100 feet long located east of and adjacent to the mouth of the Patchogue River. The easterly 2,800 feet of shore belongs to the town of Westbrook and is used as a public bathing beach. Between 1838 and 1933 erosion caused a shore recession up to 100 feet along the easterly third of West Beach, and accretion up to 350 feet occurred along the westerly two-thirds of the shore. Between 1926 and 1932, a series of short low timber groins were constructed along the easterly 1,300 feet of the beach and they have succeeded in stabilizing that part of the shore. The next westerly 1,000 feet of beach is entirely unprotected and small amounts of shore recession have occurred since 1933. Thence, for about 500 feet a masonry wall exists at the edge of the water. Three groins have been built in front of this wall and they have impounded a small amount of westward moving littoral drift. The shore for about 1,000 feet west of this wall receded about 50 feet between 1933 and 1949, necessitating protection of the western end of the aforementioned wall by the placement of riprap revetment. West of this eroding portion of the beach, there has been accretion of about 100 feet since 1933. During the spring of 1950, fill was placed imme-

diately west of the public beach and a row of cottages was built in the fill area closely bordering the shore. The fill reportedly consisted of 1,000 cubic yards of hard packed, gravelly, stony material placed in a triangular area so as to move the shore line out to the line of the adjoining sea wall at its east end with the beach widening, diminishing progressively to a point of no change 100 feet west of the wall. It was noted from inspections that from June to November erosion caused the high water line to retreat about 25 feet along the fill area adjacent to the wall. A few weeks later, on November 25, 1950, a southeast storm caused an additional shore line retreat of about 25 feet. This storm washed large quantities of sand landward, caused serious damage to the new cottages and destroyed sections of the sea wall at the public beach adjoining the fill area. The problem consists of providing protection for the new cottage development and the adjoining walled portion of the public beach. The plan considered consists of direct placement of sand fill along the shore in these areas to form a protective beach. Consideration was given in a preliminary plan to construction of a system of groins to reduce losses of existing beach material and to impound a protective beach through drifting. The existence of offshore shoals indicates that the area is one of deposition. Trailing underwater bars indicate that losses of beach material occur through offshore movement and that deposition of drifting material largely occurs offshore. It appears that the rate of loss of the proposed fill will not be rapid and that periodic replacement of losses of fill will be more economical than groin construction. Actual losses of fill by westward drifting in excess of those anticipated could make groin construction economically justifiable. The plan of protection is shown on plate 17.

29. *Grove Beach*.—This is a sandy privately owned shore about 4,000 feet long located west of and adjacent to the mouth of the Patchogue River. The west end of the beach merges into a coarse sand and gravel and boulder strewn shore. The easterly 800 feet of shore at Grove Point is the outer end of a recurved sand spit which receded about 300 feet northward between 1838 and 1933. This point is occupied by cottages fronted by a masonry wall and a series of short timber groins. These protective structures have held the shore so that there has been no recession of the high-water line since 1933. The groins retard erosion and have prevented undermining and destruction of the walls, but they have not been successful in catching sufficient material to build a fronting sand beach. The remainder of Grove Beach consists of sand varying in width from 50 to 100 feet above the high-water line. Additional protection is needed at the eastern end of the beach to insure against undermining of the walls and protection of the cottage development. The plan of protection considered consists of construction of an impermeable groin extending in a southerly direction from the eastern end of Grove Point to catch eastward moving littoral drift. Such a groin would result in building up a protective beach in front of the walls. The position and alignment of the groin coincides with that of a jetty which is being considered in a survey report authorized by River and Harbor Act dated July 24, 1946, for development of Patchogue River for navigation purposes. In the event that the jetty is constructed before action is taken in regard to the groin construction, the jetty would serve the purposes of shore protection and no additional construction would

be required. A wide inshore horizontal berm section of the groin is necessary to prevent passage of material and to impound a wider accretion at the groin and a consequent longer westward extension of the accretion in front of the cottages which now have a narrow beach. The plan of protection is shown on plate 18.

30. *Clinton Beach.*—This is an extent of privately owned shore about 8,300 feet long located between the Westbrook-Clinton town line and Kelsey Point. The easterly 1,700 feet of shore is rock and boulder strewn, and the backshore is continuously protected by sea walls. The coarse nature of the beach and the existing walls provide adequate protection to this part of the shore. The remainder of Clinton Beach, except adjacent to Kelsey Point, is sandy in composition and is characterized by a continuous system of closely spaced groins. These groins have retarded erosion which, in places, resulted in a shore recession of about 200 feet between 1838 and 1933. There has been little movement in the position of the high-water line since 1933. The existing beach is generally over 50 feet wide above high water. If additional protection or improvement of the beach for recreational use is desired in this area, it is practical to effect this by placing sand directly on the beach so as to fill the spaces between existing groins which do not now impound material to the limit of their capacity. The beach width decreases along the westerly end of the beach so that adjacent to Kelsey Point high water is at or very close to existing sea walls and the composition of shore material is generally coarse. Due to their proximity to the more exposed outer end of Kelsey Point, the groins along this westerly portion of the beach are less effective than elsewhere. Increasing the length of groins at this end of the beach would provide greater protection against erosion. It is unlikely that any considerable amount of drift material would be caught by the groins since there is no apparent source of supply of such material. It is not practical to create a sandy beach near Kelsey Point by direct placement of sand because of the exposed location and the consequent difficulty of retaining loose unconsolidated material. Existing structures have stabilized the shore in recent years. No new construction is necessary at the present time.

31. *Kelsey Point to Hammock Point.*—This is an extent of privately owned shore about 3,600 feet long. Kelsey Point is protected by high masonry sea walls and the fronting beach is composed of cobbles and boulders. The existing structures appear adequate for protection of the point. West of Kelsey Point, there is a sandy cusped-shaped beach having a maximum width of about 150 feet in its central portion diminishing in width toward the east and west ends where the high-water line is at the foot of sea walls. This sandy beach has formed since 1883. In recent years, it was reportedly growing. Photographic evidence shows that erosion is occurring along the easterly part and accretion along the westerly part of the beach, indicating a gradual westward movement of sand. Formation of the beach is believed to be due to construction of Kelsey Point breakwater which affords protection from southwest winds which cause the principal movement of shore material. The sand appears to have accumulated as a result of eastward littoral drifts from the shore to the west as far as Hammock Point and westward drift from Kelsey Point. Depletion of sources of drift material from the west is probably

responsible for the recent trend towards westward movement of the beach. During 1949 the Beach Park Point Association which owns the easterly half of this sandy beach became concerned over loss of sand and deterioration of the beach. The association constructed a timber groin immediately east of the apex of the beach. This groin has succeeded in impounding sand and effecting a beach widening of about 50 feet. No additional improvement is considered necessary. The shore west of this sandy beach is protected by massive sea walls. Hammock Point is protected by heavy dumped riprap. There is no beach in front of these protective structures. This shore area has been subject to severe storm attack and erosion which has necessitated repeated reconstruction of protective structures. H. S. Sharp, in his report *The Physical History of the Connecticut Shoreline*, dated 1929, describes existing walls as "very expensive structures." These structures were almost completely destroyed during the 1938 hurricane and have since been rebuilt. Erosion is continuing in front of the walls resulting in lowering of the beach level. A series of short groins have been built in front of the walls but they have not been successful in stopping erosion. Additional protection is required for this shore area to avoid repetition of past damages. Various plans were considered. The most economical method of protection would be placement of riprap revetment along the toes of the sea walls. This plan is shown on plate 18. Consideration was given to a plan involving construction of a breakwater extending from Hammock Point to a point about halfway to the Kelsey Point breakwater. Such a structure would shelter the shore from southwest winds and would stop the predominant eastward drift responsible for erosion. The beach could then be restored by artificial placement of sand. Such a beach would probably be fairly stable. Due to the large quantity of material required for such a breakwater and the great expense involved, this plan could not be justified economically. Consideration was given in a preliminary plan to direct placement of sand fill without a breakwater to create a protective beach in front of the sea walls. A series of groins would be necessary under this plan to reduce the rate of loss of the fill. This latter method, though more expensive than revetment, may be preferable to property owners who desire a recreational beach.

32. *East shore Clinton Harbor.*—The east shore of Clinton Harbor between Hammock Point and Hammock River consists of a sand bar or dune fronting marsh. There is very little development along this area. There is a town-owned public bathing beach adjacent to Hammock River. This public beach is fronted by extensive sand flats which detract from its value as a bathing beach. Some improvement is desired to remedy this situation. Since this is not a problem of shore protection, correction of this condition has not been considered. Due to the lack of development and the unsuitability of the area for development, no plan of improvement is considered necessary at the present time.

IV. ECONOMIC ANALYSIS

33. *General.*—Economic analyses have been made for all contemplated projects. Detailed estimates of costs are included in appendix H and detailed estimates of benefits are included in appendix I. Where public and private shore areas are included in one integrated

improvement, the analyses have been made for the combined area. Analyses have been restricted to the immediate area to be improved. Improvements have been considered as follows:

Improvements considered

Area	Ownership	Paragraph reference	Plate
Borough of Fenwick, (West part), Old Saybrook.	Combined public and private...	14	15
Plum Bank Beach, Old Saybrook.....	do.....	16	16
Great Hammock Beach, Old Saybrook.....	Private.....	17	16
Saybrook Manor, Old Saybrook.....	do.....	18	16
Chalker Beach, Old Saybrook.....	do.....	20	16
Chapman Beach, Westbrook.....	do.....	21	16
West Beach, Westbrook.....	Combined public and private...	28	17
Grove Beach, Westbrook.....	Private.....	29	18

34. *First costs.*—The first costs of the projects considered, computed in detail in appendix H, are as follows:

Project	Quantity	Cost
Borough of Fenwick, (west part).....	6,000 tons riprap wall.....	\$34,500
Plum Bank Beach.....	61,000 cubic yards sand fill, 1,850 tons riprap groin.....	59,000
Great Hammock Beach.....	19,000 cubic yards sand fill.....	22,000
Saybrook Manor.....	11,000 cubic yards sand fill.....	12,500
Chalker Beach.....	73,000 cubic yards sand fill.....	50,000
Chapman Beach.....	46,000 cubic yards sand fill.....	34,500
West Beach.....	do.....	34,500
Grove Beach.....	2,500 tons riprap groin.....	23,000

35. *Benefits.*—The benefits anticipated from the plans of improvement are estimated on the recreational value of increased public beach area, direct damages prevented and increased earning power or value of shore lands. Benefits from increased value of areas behind and adjacent to improved shore property, increased business and recreational value in improvement of private beaches, although known to exist, have not been estimated. Recreational benefit has been evaluated for anticipated increased public beach patronage by assigning a per capita value for beach use, estimated as the minimum fee which patrons would be required to pay if the beach was a private enterprise. Direct damages prevented have been evaluated in terms of the value of area of land which would normally be lost through erosion, by estimating the savings in maintenance costs of existing protective structures and estimating the savings effected through prevention of damages to buildings located close to the shore. Benefits from increased earning power or value of shore lands have been evaluated by estimating the increase in tax on improved land due to increase in value of the property and also by taking a gain represented by interest on increase in land value which could be realized by sale of such land and investment of the additional money so obtained.

36. Detailed estimates of annual benefits are included in appendix I and are summarized below:

Estimated annual benefits

Project	Recreational	Direct damages prevented	Increased earning power	Total
Borough of Fenwick (west part).....	0	\$899	0	\$899
Plum Bank Beach.....	\$200	3, 635	\$2, 324	6, 159
Great Hammock Beach.....	0	562	876	1, 438
Saybrook Manor.....	0	400	548	948
Chalker Beach.....	0	1, 475	2, 078	3, 553
Chapman Beach.....	0	1, 070	932	2, 002
West Beach.....	0	2, 175	325	2, 500
Grove Beach.....	0	940	410	1, 350

37. *Federal, non-Federal public and private interests.*—The Federal interest in a shore-protection project is considered to be essentially the benefit secured by the United States as a landowner. Non-Federal public interest is defined as (a) the benefits accruing to a State of a political subdivision thereof as a landowner; and (b) the benefits accruing to the general public. Private interest is defined as the benefit derived by individuals or nonpublic groups of individuals on account of ownership of lands and business enterprises affected.

38. The classification of benefits to be derived from the proposed projects in accordance with the interest involved is as follows:

Estimated annual benefits

Project	Federal	Non-Federal public	Private	Total
Borough of Fenwick (west part).....	0	\$220	\$679	\$899
Plum Bank Beach.....	0	1, 095	5, 064	6, 159
Great Hammock Beach.....	0	176	1, 262	1, 438
Saybrook Manor.....	0	110	838	948
Chalker Beach.....	0	418	3, 135	3, 553
Chapman Beach.....	0	182	1, 820	2, 002
West Beach.....	0	1, 250	1, 250	2, 500
Grove Beach.....	0	80	1, 270	1, 350

39. *Allocation of costs.*—The Federal policy for the expenditure of Federal funds for the improvement and protection of shores owned by States, municipalities, and other political subdivisions is set forth in Public Law 727, Seventy-ninth Congress, second session. In accordance with this policy, the Federal share of the cost can equal but not exceed one-third of the first cost of construction, but not the maintenance, of works for the improvement and protection of publicly owned shores. No policy has been established for Federal participation in the first cost of works for the protection and improvement of privately owned shores and no Federal contribution of funds has been considered for this purpose. No Federal contribution of funds has been computed where the area to be protected and improved is divided between public and private ownership and no use of the publicly owned portion of the shore is made or contemplated, or the publicly owned shore is so small in extent that the maximum allowable Federal contribution of funds would represent only a minor amount of the cost of the considered project.

40. The Federal and non-Federal share of the costs of projects considered are estimated in detail in appendix H and are summarized below:

Allocation of costs

Project	Federal share	Non-Federal share	Total
Borough of Fenwick (west part).....	0	\$34,500	\$34,500
Plum Bank Beach.....	0	59,000	59,000
Great Hammock Beach.....	0	22,000	22,000
Saybrook Manor.....	0	12,500	12,500
Chalker Beach.....	0	50,000	50,000
Chapman Beach.....	0	34,500	34,500
West Beach.....	\$6,900	27,600	34,500
Grove Beach.....	0	23,000	23,000

41. *Federal and non-Federal annual charges.*—Annual charges are based on the Federal and non-Federal share of the estimated costs of proposed projects. The detailed estimates are included in appendix H. Interest has been computed at the rate of 3 percent on Federal funds and 3.5 percent on non-Federal funds. A useful life of 50 years has been assumed in determining amortization charges. Annual maintenance costs are included as a non-Federal charge. A summary of annual charges is given below:

Annual charges

Project	Federal	Non-Federal	Total
Borough of Fenwick (west part).....	0	\$1,710	\$1,710
Plum Bank Beach.....	0	3,915	3,915
Great Hammock Beach.....	0	1,240	1,240
Saybrook Manor.....	0	840	840
Chalker Beach.....	0	2,930	2,930
Chapman Beach.....	0	2,670	2,670
West Beach.....	\$270	2,580	2,850
Grove Beach.....	0	1,230	1,230

42. *Benefit and cost ratio.*—The estimated annual benefits and costs and the resulting ratio of benefits to costs are summarized below:

Benefits and costs

Project	Estimated annual benefits	Estimated annual costs	Ratio of benefits to costs
Borough of Fenwick (west part).....	\$899	\$1,710	0.5
Plum Bank Beach.....	6,159	3,915	1.5
Great Hammock Beach.....	1,438	1,240	1.1
Saybrook Manor.....	948	840	1.1
Chalker Beach.....	3,553	2,930	1.2
Chapman Beach.....	2,002	2,670	.7
West Beach.....	2,500	2,850	.9
Grove Beach.....	1,350	1,230	1.1

43. *Coordination with other agencies.*—Close coordination has been maintained with the Connecticut State Flood Control and Water Policy Commission, the official agency representing the State of Connecticut in this cooperative study. The Connecticut Beach Erosion Advisory Committee appointed by the Governor to report to the State

legislature has in like manner been advised and consulted. The selectmen of the towns concerned have been contacted and their views sought. The Connecticut Development Commission, State Park Department, State Highway Department and State Board of Fisheries and Game have been contacted as to aspects of the study pertaining to their interests. In addition, widespread personal contact has been made with shore residents to ascertain data concerning the problem.

44. *Comments by local interests.*—The proposed plans have been discussed with the Connecticut State Flood Control and Water Policy Commission. A meeting was arranged by the cooperating agency at which the proposed plans were explained to town officials and interested parties. There was a general concurrence in the proposed plans.

V. DISCUSSION AND CONCLUSIONS

45. *Borough of Fenwick (west part).*—This area consists of a stretch of coarse eroded shore which is largely unprotected. The shore has been subject to considerable erosion, resulting in a loss of beach material and recession of the high water line. The backshore is partly developed for residential use. Continued recession of the shore will endanger existing residences. The residences are located far enough behind the shore at present so that they are in no immediate danger. Headlands which formerly supplied material to the beach are now protected. The absence of littoral drift precludes the possibility of creating a protective beach by construction of groins to impound drifting material. The specific need consists of prevention of continued shore recession. The plan considered most practicable is the construction of a dumped riprap wall along the mean high water line with a top elevation high enough to provide protection against ordinary storm tides. This wall will be overtopped during infrequent storms and some water damage will undoubtedly occur to the area behind it. The wall should serve the intended purpose of maintaining the present position of the high-water shore line.

46. The estimated first cost of construction of the wall is \$34,500, and the estimated annual maintenance is \$240. The estimated annual cost is \$1,710 and the annual benefit is \$899. The ratio of benefits to costs is 0.5 to 1. The public interest amounts to an annual non-Federal public benefit of \$220. Ownership of the area to be protected is 25 percent public and 75 percent private. There is no public use made of the publicly owned shore and so far as is known, none is contemplated. Due to the limited public interest involved, no Federal participation in the cost of protective works is warranted.

47. *Plum Bank Beach.*—This beach consists of a low sandy barrier bar extending northwestward from Cornfield Point, formed through erosion of Cornfield Point and northward drifting of the eroded material. Cornfield Point is now largely protected and no longer supplies any appreciable amount of littoral drift. Plum Bank Beach is protected by a series of very closely spaced groins which hold material on their south sides, forming an irregular sawtoothed-shaped shore, indicating the existence of northward-moving littoral drift. Extensive sand flats front the beach, indicating that the foreshore is an area of deposition. The lack of major changes in the position of the high-water shore line during the period of record further indicates that the

rate of loss of beach material is small. The sand beach is narrow and low in elevation and lies in front of low walls and revetment which protects a row of cottages located behind the narrow beach. The low, narrow beach and existing structures do not provide satisfactory protection to the cottage development. The plan considered most practicable for providing additional protection consists of placing a wider and higher sand beach in front of the cottages by hydraulic dredging from offshore areas. Construction of a system of groins to retard erosion of the fill was considered. Due to the past low rate of loss of beach material, it appears that it would be more economical to maintain the fill by periodic replenishment of sand losses. Due to the existence of northward drifting, movement of the sand fill would tend to close the mouth of Plum Bank Creek. A terminal groin at the north end of the fill is considered necessary to prevent this.

48. The estimated first cost of construction of the beach and terminal groin is \$59,000, and the estimated annual maintenance is \$1,400. The estimated annual cost is \$3,915, and the annual benefit is \$6,159. The ratio of benefits to costs is 1.5 to 1. The public interest amounts to an annual non-Federal public benefit of \$1,095. Ownership of the area to be protected is 5 percent public and 95 percent private. The extent of publicly owned shore is so small that the maximum allowable Federal contribution of funds under public law would represent only a minor amount of the cost of the considered project. No Federal contribution of funds is warranted.

49. *Great Hammock Beach.*—This is a low-lying marshy shore which underwent considerable recession between 1838 and 1933. In recent years, shore line changes have been small in magnitude. The back-shore is subject to flooding during extreme high tides. There is a development behind the central portion of the beach consisting of about 50 cottages. Some of these cottages are located very close to the edge of the water and could be destroyed by continued recession of the shore. Protection at present consists of a low riprap mound along the edge of the water which acts as a wave breaker. Complete protection of the cottage development against flooding would require the construction of some form of dike or wall around its perimeter. Since the purpose of such protection would be largely flood control, consideration of such a plan is regarded as being beyond the scope of this report. Consideration has been given to providing protection to the shore-front cottages against erosion and storm damage. The plan considered most practicable consists of placing a sand beach or dune in front of the cottages by hydraulic dredging of offshore material. Consideration was given to construction of an impermeable groin at the north limit of this fill to reduce losses of material through northward drifting. Since changes in the position of the shore line in recent years have been small, it appears that losses of the sand fill would be small and it would be more economical to maintain the fill by periodic replacement of losses.

50. The estimated first cost of the fill is \$22,000, and the estimated annual maintenance is \$300. The estimated annual cost is \$1,240, and the annual benefit is \$1,438. The ratio of benefits to costs is 1.1 to 1. The public interest amounts to an annual non-Federal public benefit of \$176. The shore area is all privately owned. No Federal participation in the cost of protective works has been considered.

51. *Saybrook Manor*.—This shore area has undergone continued erosion and recession since 1838. The retreat of the shore has moved the high-water line landward generally to the foot of low sea walls fronting a cottage development. The problem involved consists of providing protection to the cottage development, and improving the beach for recreational use. Absence of littoral drift precludes the possibility of impounding a beach by construction of groins. The most practicable plan of protection and improvement consists of direct placement of a wider and higher sand beach in front of the cottage development. Since the past rate of loss of beach material has been comparatively low, it appears that the fill can be maintained more economically by periodic replacement of losses rather than by construction of groins to reduce losses.

52. The estimated first cost of the fill is \$12,500, and the estimated annual maintenance is \$300. The estimated annual cost is \$840, and the annual benefit is \$948. The ratio of benefits to costs is 1.1 to 1. The public interest amounts to an annual non-Federal public benefit of \$110. The shore area is all privately owned. No Federal participation in the cost of protective works has been considered.

53. *Chalker Beach*.—The westerly two-thirds of this beach has undergone erosion and recession between 1838 and 1933, but has been comparatively stable since 1933. This portion of the beach is occupied by a row of closely spaced cottages located at or very close to the high-water line. The fronting beach is low in elevation. The cottages are protected by bulkheads and rows of piles which act as wave breakers. The cottage development is subject to wave attack and flooding and consequent damage. The problem involved is to provide protection against this damage. The plan of protection considered most practicable consists of direct placement of a higher and wider sand beach in front of the cottage development. Construction of groins to reduce losses of the fill has been considered. The past rate of loss of beach material has been comparatively low. It, therefore, appears that the fill can be maintained more economically by periodic replacement of losses.

54. The estimated first cost of the fill is \$50,000, and the estimated annual maintenance is \$800. The estimated annual cost is \$2,930, and the annual benefit is \$3,553. The ratio of benefits to costs is 1.2 to 1. The public interest amounts to an annual non-Federal public benefit of \$418. The shore area is all privately owned. No Federal participation in the cost of protective works has been considered.

55. *Chapman Beach*.—This beach consists of two pockets or compartments in the shore separated by a bedrock outcrop. The easterly pocket was formed by erosion and recession of the shore between 1838 and 1933. There has been little change in the position of the shore line in this pocket since 1933. The shore line of the westerly pocket has not undergone any large changes during the period of record, i. e., since 1838. This beach is now protected by a series of groins which hold material on their west sides, forming an irregular shore line. Development of the area consists of residences on an eroding bluff behind the westerly pocket beach and residences along the westerly end of the easterly pocket behind low deteriorating walls. Consideration has been given to providing additional protection to the resi-

dential development and improvement of the present unsatisfactory beach for recreational use. The plan considered most practicable is the direct placement of a higher and wider sand beach in front of the residential development. Consideration was given to construction of groins to reduce losses of the sand fill. The low past rate of loss of beach material indicates that the fill can be maintained more economically by periodic replacement of losses.

56. The estimated first cost of the fill is \$34,500, and the estimated annual maintenance is \$1,200. The estimated annual cost is \$2,670, and the annual benefit is \$2,002. The ratio of benefits to costs is 0.7 to 1. The public interest amounts to an annual non-Federal public benefit of \$182. The shore area is all privately owned. No Federal participation in the cost of protective works has been considered.

57. *West Beach.*—The history of this beach has been one of erosion along its easterly end and accretion along its westerly end. Construction of a series of timber groins along the easterly 1,300 feet of the beach between 1926 and 1932 stabilized that portion of the shore and apparently reduced the supply of littoral drift material formerly moving westward and nourishing the beach further west. This resulted in a westward extension of the erosion area and reduced the length of shore at the west end of the beach which continued to prograde. A sea wall along the edge of the water fronted by three short groins exists along 500 feet of shore in the erosion area. This sea wall has been subject to damage by undermining and wave attack. West of the sea wall for about 1,000 feet, there was erosion and recession of the shore of 50 feet between 1933 and 1949. During 1950 fill was placed along a short section of shore adjacent to the sea wall and a row of cottages was built closely bordering the shore at the fill area. Within a few months, partly as a result of the natural processes of erosion and partly because of sand losses during the exceptionally severe storm of November 1950, the fill was lost and serious damage occurred to the new cottage development. The problem consists of providing protection to the walled section of beach and the cottage development located west of and adjacent to it. The plan considered most practicable is direct placement of sand in front of the wall and cottages to create a protective beach. Consideration was given to construction of a series of groins to retard loss of this fill. The existence of offshore shoals and underwater bars trailing seaward indicates that material is lost through offshore movement and that this material is deposited in the offshore area. It appears that periodic replacement of sand losses will be a more economical method of maintaining the fill. In the event that sand losses through westward drifting exceed those anticipated, groin construction could be economically justified. No consideration was given to enlargement of the beach for recreational use since the space now available is adequate to accommodate all bathers using or anticipated to use the beach.

58. The estimated first cost of the fill is \$34,500, and the estimated annual maintenance is \$1,400. The estimated annual cost is \$2,850, and the annual benefit is \$2,500. The ratio of benefits to costs is 0.9 to 1. The public interest amounts to an annual non-Federal public benefit of \$1,250. The shore area to be protected and improved is 60 percent public and 40 percent private. The public shore belongs to the town of Westbrook and is used as a public bathing beach.

Federal participation in the cost of protective works has been considered for that portion of the shore which belongs to the town of Westbrook.

59. *Grove Beach*.—The easterly end of this beach is the outer end of an eastward trailing sand spit which recurved to the north and receded landward about 300 feet between 1838 and 1933. The bar is held in its present position by a masonry wall constructed along its soundward shore. This wall is fronted by a series of short timber groins which retard erosion and undermining of the wall but have not been successful in catching sufficient material to build a fronting sand beach. The wall is subject to damage from wave action. The area behind the wall is occupied by cottages. The problem consists of providing protection of a nature that will insure against undermining and destruction of the wall and damage to the cottage development. The plan considered most practicable consists of construction of an impermeable groin extending in a southerly direction from the eastern end of Grove Point to intercept easterly moving littoral drift and impound a protective beach in front of the walls. Sources of littoral drift material have been determined to exist along the sandy unprotected beach located west of and adjacent to the area to be protected. The position and alinement of the groin coincides with that of a jetty which is being considered in connection with a study for development of Patchogue River for navigation purposes, authorized by River and Harbor Act, dated July 24, 1946. The jetty, if constructed prior to the groin, would serve the purposes of shore protection and no additional construction would be required.

60. The estimated first cost of construction of the groin is \$23,000, and the estimated annual maintenance is \$250. The estimated annual cost is \$1,230, and the annual benefit is \$1,350. The ratio of benefits to costs is 1.1 to 1. The public interest amounts to an annual non-Federal public benefit of \$80. The shore area is all privately owned. No Federal participation in the cost of protective works has been considered.

61. *Conclusions*.—The division engineer concludes that the best plans for protection and improvement of beaches within the study area, all as shown on plates 15 to 18, are as follows:

(a) *Borough of Fenwick (west part)*.—Construction of a dumped riprap wall along the high water shore line.

(b) *Plum Bank Beach*.—Direct placement of a protective sand beach in front of the sea walls and cottages, and construction of an impermeable groin at the north limit of the fill.

(c) *Great Hammock Beach*.—Direct placement of a protective sand beach or dune in front of the cottage development.

(d) *Saybrook Manor*, (e) *Chalker Beach*, and (f) *Chapman Beach*.—Direct placement of a protective sand beach in front of the cottage or residential developments.

(g) *West Beach*.—Direct placement of a protective sand beach in front of the sea wall along the west end of the public beach and in front of the cottage development west of and adjacent to the sea wall.

(h) *Grove Beach*.—Construction of an impermeable groin at the east end of the beach.

62. Economic analyses indicate that the proposed plans for Plum Bank Beach, Great Hammock Beach, Saybrook Manor, Chalker Beach, and Grove Beach are justified by evaluated benefits. Except

for a small portion of Plum Bank Beach which belongs to the town of Old Saybrook, the above shore areas are privately owned. No policy has been established by public law for Federal contribution of funds for protection and improvement of privately owned shores and no such contribution has been considered. The publicly owned portion of Plum Bank Beach is so small that the maximum allowable Federal contribution of funds under Public Law 727, Seventy-ninth Congress, second session, would amount to only a minor amount of the entire first cost of the proposed project. It is, therefore, not considered advisable for the United States to adopt a Federal project for protecting and improving Plum Bank Beach. It is considered advisable for local interests to adopt the proposed projects for protection and improvement of the above beaches.

63. Economic analyses indicate that the proposed plans for the Borough of Fenwick (west part), Chapman, and West Beaches are not justified by evaluated benefits. The plans for the Borough of Fenwick (west part) and for West Beach involve protection of shore areas which are, in part, publicly owned. Due to lack of sufficient economic justification, it is not advisable for the United States to adopt projects for protecting these publicly owned shores. Benefits which have not been evaluated or cannot be evaluated in monetary terms may make it advisable for local interests to adopt the projects considered. If local interests desire to protect and/or improve the above beaches, consideration should be given to the plans that have been developed.

VI. RECOMMENDATIONS

64. *Recommendations.*—It is recommended that local interests consider protection and improvement of beaches in accordance with the specific plans discussed in paragraphs 12 to 32, inclusive, and as shown on plates 15 to 18, inclusive.

65. It is recommended that local interests adopt projects for the following plans of protection and improvement, as shown on plates 15, 16, and 18.

(a) *Plum Bank Beach, Old Saybrook.*—Direct placement of sand fill to form a protective beach along 3,500 feet of shore south of and adjacent to Plum Bank Creek, and construction of an impermeable groin 450 feet long at the north limit of the fill.

(b) *Great Hammock Beach, Old Saybrook.*—Direct placement of sand fill to form a protective beach or dune along 800 feet of shore in front of the cottage development.

(c) *Saybrook Manor, Old Saybrook.*—Direct placement of sand fill to form a protective beach along 650 feet of shore in front of the cottage development.

(d) *Chalker Beach, Old Saybrook.*—Direct placement of sand fill to form a protective beach along 2,100 feet of shore in front of the cottage development.

(e) *Grove Beach, Westbrook.*—Construction of an impermeable groin 400 feet long at the east end of the beach at Grove Point.

66. It is not advisable for the United States to adopt a project authorizing Federal contribution of funds for protection or improvement of any of the beaches considered.

H. J. WOODBURY,
Colonel, Corps of Engineers,
Division Engineer.

LIST OF APPENDIXES MADE IN CONNECTION WITH THE REPORT
OF THE DIVISION ENGINEER

(Only appendixes H and I printed)

- A. Description and composition of beaches.
- B. Geology.
- C. Tides.
- D. Storms.
- E. Shore line and offshore depth changes.
- F. Littoral drift.
- G. Existing protective structures.
- H. Estimates of costs of improvements.
- I. Estimates of benefits from improvements.
- J. Pollution along the Connecticut shore.

LIST OF PLATES MADE IN CONNECTION WITH THE REPORT OF
THE DIVISION ENGINEER

(Only plates 1, 6 to 9, 11 to 18 printed)

- 1. Location (map).
- 2. Hurricanes and prevailing winds.
- 3. Wind data, Block Island.
- 4. Wind data, New Haven.
- 5. Wind data, New York.
- 6. Shore structures, typical construction details.
- 7. Shore line and offshore depth changes, sheet 1.
- 8. Shore line and offshore depth changes, sheet 2.
- 9. Shore line and offshore depth changes, sheet 3.
- 10. Comparative profiles.
- 11. Survey map, sheet 1.
- 12. Survey map, sheet 2.
- 13. Survey map, sheet 3.
- 14. Survey map, sheet 4.
- 15. Plans of improvement, sheet 1.
- 16. Plans of improvement, sheet 2.
- 17. Plans of improvement, sheet 3.
- 18. Plans of improvement, sheet 4.
- 19. Photographs, Lynde Point and Fenwick.
- 20. Photographs, Fenwick and Knollwood.
- 21. Photographs, Knollwood, Plum Bank, and Great Hammock Beaches.
- 22. Photographs, Saybrook Manor and Chalker Beach.
- 23. Photographs, Chapman Beach and Old Kelsey Point.
- 24. Photographs, Salt Works Bay, Stannard and Little Stannard Beaches.
- 25. Photographs, Middle and Quotonset Beaches.
- 26. Photographs, West and Grove Beaches.
- 27. Photographs, Clinton Beach.
- 28. Photographs, Clinton Beach and Kelsey Point.
- 29. Photographs, Beach Park.
- 30. Photographs, Hammock Point and East Shore Clinton Harbor.

APPENDIXES

APPENDIX H. ESTIMATE OF COSTS OF IMPROVEMENTS

1. *General.*—The estimated life of the considered projects is 50 years. The rate of interest on Federal investments is computed at 3 percent and on non-Federal investments at 3.5 percent. Maintenance requirements of sand fills are based on maximum rates of loss determined from past shore recession. Where sand fill is proposed for a shore composed of coarse material which is now more resistant to erosion than sand, an estimated rate of loss twice as great as previously experienced has been used. Where sand fill is proposed for a shore now sandy in composition, a rate of loss equal to the maximum estimated past rate has been used. A minimum rate of shore recession of 1 foot per year has been used as a basis for estimates of losses for all sand fills.

2. *Borough of Fenwick (west part).*—The plan for protection consists of construction of a riprap mound along 2,000 feet of shore at the west end of the Borough of Fenwick.

(a) *First costs*—

6,000 tons riprap at \$5.....	\$30, 000
Engineering and contingencies.....	4, 500
Total cost.....	34, 500

(b) *Annual charges.*—Approximately 25 percent of the shore to be protected belongs to the Borough of Fenwick. No public use is made of this shore and none is contemplated. In view of the limited amount of public interest involved in protection of the shore, no Federal participation in the cost of protective works has been computed.

Non-Federal annual charges:

Interest.....	\$1, 210
Amortization.....	260
Annual maintenance, 30 tons riprap, at \$8.....	240

Total annual charges.....	1, 710
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3. *Plum Bank Beach.*—The plan for protection and improvement consists of widening 3,500 feet of beach by direct placement of sand and construction of an impermeable groin at the north limit of the fill.

(a) *First costs*—

61,000 cubic yards sand at \$0.60.....	\$36, 600
1,850 tons riprap at \$8.....	14, 800
Engineering and contingencies.....	7, 600

Total cost.....	59, 000
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(b) *Annual charges.*—Approximately 5 percent of the entire area to be protected belongs to the town of Old Saybrook. The remainder of the shore is privately owned. The maximum allowable Federal

participation in the first cost of construction (one-third of 5 percent) is small. Because of the limited public interest involved in the plan of protection, no Federal participation in the cost of protective works has been computed.

Non-Federal annual charges:

Interest.....	\$2, 065
Amortization.....	450
Annual maintenance:	
Sand losses, 1,200 cubic yards, at \$1.....	1, 200
Groin repairs, 20 tons, at \$10.....	200
Total annual charges.....	3, 915

4. *Great Hammock Beach*.—The plan for protection and improvement consists of construction of a protective sand beach along 800 feet of shore by direct placement of sand fill.

(a) *First costs*—

19,000 cubic yards sand, at \$1.....	\$19, 000
Engineering and contingencies.....	3, 000
Total cost.....	22, 000

(b) *Annual charges*.—The entire shore is privately owned. No Federal participation in the cost has been considered.

Non-Federal annual charges:

Interest.....	\$770
Amortization.....	170
Annual maintenance, sand losses, 300 cubic yards, at \$1.....	300
Total annual charges.....	1, 240

5. *Saybrook Manor*.—The plan for protection and improvement consists of construction of a protective sand beach along 650 feet of shore by direct placement of sand fill.

(a) *First costs*—

11,000 cubic yards sand, at \$1.....	\$11, 000
Engineering and contingencies.....	1, 500
Total costs.....	12, 500

(b) *Annual charges*.—The entire shore is privately owned. No Federal participation in the cost has been considered.

Non-Federal annual charges:

Interest.....	\$440
Amortization.....	100
Annual maintenance, sand losses, 300 cubic yards, at \$1.....	300
Total annual charges.....	840

6. *Chalker Beach*.—The plan for protection and improvement consists of construction of a protective sand beach along 2,100 feet of shore by direct placement of sand fill.

(a) *First costs*—

73,000 cubic yards sand, at \$0.60.....	\$43, 800
Engineering and contingencies.....	6, 200
Total cost.....	50, 000

(b) *Annual charges*.—The entire shore is privately owned. No Federal participation in the cost has been considered.

Non-Federal annual charges:

Interest	\$1, 750
Amortization	380
Annual maintenance, sand losses, 800 cubic yards, at \$1	800

Total annual charges

2, 930

7. *Chapman Beach*.—The plan for protection and improvement consists of construction of a protective sand beach along 1,500 feet of shore by direct placement of sand fill.

(a) *First costs*—

46,000 cubic yards sand, at \$0.65	\$29, 900
Engineering and contingencies	4, 600

Total cost

34, 500

(b) *Annual charges*.—The entire shore is privately owned. No Federal participation in the cost has been considered.

Non-Federal annual charges:

Interest	\$1, 210
Amortization	260
Annual maintenance, sand losses, 1,200 cubic yards, at \$1	1, 200

Total annual charges

2, 670

8. *West Beach*.—The plan for protection consists of construction of a protective sand beach along 2,100 feet of shore by direct placement of sand fill.

(a) *First costs*—

46,000 cubic yards sand, at \$0.65	\$29, 900
Engineering and contingencies	4, 600

Total cost

34, 500

(b) *Annual charges*.—The town of Westbrook owns 1,300 feet of this shore and uses it for a public bathing beach. The title to 275 additional feet of shore is in question and may belong to the town of Westbrook. The remaining 525 feet is privately owned. Allocation of costs has been based on the percentage of the entire shore which is clearly owned by the town of Westbrook. Approximately 60 percent of the shore definitely belongs to the town. The Federal share of the first cost has been computed as the maximum allowable under Public Law 727 or one-third the cost of protection of the publicly owned shore. The Federal share becomes one-third of 60 percent, or 20 percent. Costs are allocated as follows:

Federal cost	\$6, 900
Non-Federal cost	27, 600

Federal annual charges:

Interest	210
Amortization	60

Total

270

Non-Federal annual charges:

Interest	970
Amortization	210
Annual maintenance, sand losses, 1,400 cubic yards, at \$1	1, 400

Total

2, 580

Total annual charges

2, 850

9. *Grove Beach*.—The plan for protection and improvement consists of construction of an impermeable groin.

(a) *First costs*.—

2,500 tons riprap, at \$8.....	\$20, 000
Engineering and contingencies.....	3, 000
Total cost.....	23, 000

(b) *Annual charges*.—The shore to be protected and improved is privately owned. No Federal participation in the cost has been considered.

Non-Federal annual charges:

Interest.....	\$805
Amortization.....	175
Annual maintenance, groin repairs, 25 tons, at \$10.....	250
Total annual charges.....	1, 230

APPENDIX I. ESTIMATES OF BENEFITS FROM IMPROVEMENTS

1. *General*.—The benefits computed herein are based on the promotion and encouragement of the healthful recreation of the people by protection and improvement of public beaches, on protection of shore property and increased earning power or value of shore lands. Benefits accruing from increased value of areas behind and adjacent to shore property, increased business returns and recreational use of privately owned shores are not evaluated.

2. *Borough of Fenwick (west part)*.—(a) *Federal benefit*.—The United States does not own land in the area. Therefore, no Federal benefit will result from the improvement.

(b) *Non-Federal public benefit*.—(1) Average annual direct damages prevented: The proposed structure will prevent loss of land by stabilization of the high-water shore line. Between 1883 and 1949 erosion caused an average recession of 1.5 feet per year in the position of the high-water line. This average recession over the length of publicly owned shore (491 feet) could result in an annual loss of 736 square feet of land (491×1.5). Based on present assessments, land in this area is valued at \$0.30 per square foot. Prevention of additional shore recession will result in an annual benefit evaluated as $736 \times \$0.30$, or \$220.

(c) *Private benefit*.—(1) Average annual direct damages prevented: Based on the average annual recession and land values described in paragraph 2 (b) (1) above, stabilization of the privately owned shore (1,509 feet) will prevent an annual loss of 2,263 square feet of land, annual benefit on which is computed as $2,263 \times \$0.30$, or \$679.

(d) *Summary of benefits, Borough of Fenwick*.—

Benefit	Federal	Non-Federal public	Private	Total
Direct damages prevented.....	0	\$220	\$679	\$899

3. *Plum Bank Beach*.—(a) *Federal benefit*.—The United States does not own land in the area. Therefore, no Federal benefit will result from the improvement.

(b) *Non-Federal public benefit.*—(1) Average annual direct damages prevented: The public beach is protected by a masonry wall and two timber groins. The placement of fill will provide additional protection. Benefit therefrom is computed as a saving in maintenance cost of protective structures.

120 foot masonry wall, value.....	\$1, 000
340 linear feet timber groins, value.....	3, 800
Annual wall maintenance at 5 percent.....	50
Annual groin maintenance at 10 percent.....	380
Total maintenance or benefit.....	430

(2) Benefit from increased earning power or value of land: The improvement will result in increased value of shore land. Public benefit therefrom will be derived from increased taxes on privately owned land.

Benefit from increased taxes

Assessed value of privately owned land.....	\$84, 700
Estimated increase in assessed value due to improvement, 25 percent or.....	21, 175
Tax rate \$22 per thousand, estimated tax increase.....	465

(3) *Recreational benefit:* The improvement will more than double the available bathing beach area at the public beach. Annual attendance is approximately 4,000 persons per summer season. It is assumed that the improved larger beach will attract more people. It is estimated that attendance will increase 25 percent. The recreational value per person for beach use is evaluated as the minimum fee which patrons would be required to pay if the beach was a private enterprise. This is estimates as \$0.20 per person. The increase in recreational value becomes $\frac{1}{4} \times 4,000 \times \$0.20 = \$200$.

(c) *Private benefit.*—(1) Average annual direct damages prevented: Privately owned property is protected by sea walls, bulkheads, revetments, and groins. The improvement will provide additional protection eliminating the need for most of the existing structures. Benefit therefrom is computed as a saving in maintenance cost of existing structures.

Structure	Length (feet)	Estimated value	Estimated annual maintenance cost
Sea walls.....	2, 200	\$33, 000	\$1, 650
Revetment.....	500	7, 500	375
Bulkhead.....	90	900	90
Timber groins.....	1, 400	7, 000	700
Concrete groins.....	200	2, 000	100
Riprap and masonry groins.....	580	5, 800	290
Total estimated savings.....			3, 205

(2) Benefit from increased earning power or value of land: The improvement will result in increased value of shore land. The assessed value of privately owned land to be improved is \$85,000. The real value of this land is \$212,500. The estimated increase in value is 25 percent, or \$53,125. Benefit from this increase is computed as a gain of $3\frac{1}{2}$ percent per annum. Annual benefit = $0.035 \times \$53,125 = \$1,859$.

(d) Summary of benefits, Plum Bank Beach:

Benefit	Federal	Non-Federal public	Private	Total
Direct damages prevented.....	0	\$430	\$3,205	\$3,635
Increased earning power.....	0	465	1,859	2,324
Recreational.....	0	200	0	200
Total.....	0	1,095	5,064	6,159

4. *Great Hammock Beach.*—(a) *Federal benefit.*—The United States does not own land in this area. Therefore, no Federal benefit will result from the improvement.

(b) *Non-Federal public benefit.*—(1) Increased earning power or value of land: The improvement will result in increased land value. Public benefit therefrom is computed as an increase in taxes on privately owned land.

Assessed value of land to be improved..... \$16,000
 Estimated increase in value of land due to improvement 50 percent, or..... 8,000
 Tax rate \$22 per thousand, estimated increase in taxes..... 176

(c) *Private benefit.*—(1) Average annual direct damages prevented: The shore to be improved has been subject to considerable erosion resulting in recession of the high water line and loss of beach material. Cottages located near the shore can be destroyed by continued recession of the shore. Benefit is computed as prevention of losses to shore cottages.

Prevention of losses of cottages

Assessed value of 6 shore-front cottages..... \$9,000
 Real value of 6 shore-front cottages..... 22,500
 Assuming loss of cottages in 20 years with a 50-percent salvage value,
 annual loss = $\frac{1}{2} \times 22,500 \times \frac{1}{20}$ 562

(2) Increased earning power or value of land: The improvement will result in increased value of shore land. Benefit therefrom is computed as an annual gain of $3\frac{1}{2}$ percent of this increase in value.

Assessed value of shore land..... \$16,000
 Real value of shore land..... 40,000
 Estimated increase in value, 50 percent, or..... 20,000
 Annual gain at $3\frac{1}{2}$ percent..... 700

(d) Summary of benefits, Great Hammock Beach.—

Benefit	Federal	Non-Federal public	Private	Total
Direct damages prevented.....	0	0	\$562	\$562
Increased earning power.....	0	\$176	700	876
Total.....	0	176	1,262	1,438

5. *Saybrook Manor.*—(a) *Federal benefit.*—The United States does not own land in the area. Therefore, no Federal benefit will result from the improvement.

(b) *Non-Federal public benefit.*—(1) Increased earning power or value of land: The improvement will result in increased land values. Public benefit therefrom is computed as an increase in taxes on privately owned land.

36 AREA 4, CONNECTICUT RIVER TO HAMMONASSET RIVER

Assessed value of privately owned land.....	\$10, 000
Estimated increase in land value 50 percent or.....	5, 000
Tax rate \$22 per thousand, estimated increase in taxes.....	110

(c) *Private benefit.*—(1) Average annual direct damages prevented: The improvement will protect the area resulting in a saving in maintenance cost of existing protective structures.

Savings in maintenance cost of existing protective structures

Structure	Length (feet)	Estimated value	Estimated maintenance cost
Sea walls.....	430	\$6, 500	\$325
Timber groins.....	180	500	50
Concrete and riprap groins.....	50	500	25
Total estimated maintenance cost.....			400

(2) Increased earning power or value of land: The improvement will result in increased value of shore land. Benefit therefrom is computed as an annual gain of 3½ percent of this increase in value.

Real value of shore land to be improved.....	\$25, 000
Estimated increase in value 50 percent or.....	12, 500
Annual gain at 3½ percent.....	438

(d) *Summary of benefits, Saybrook Manor.*—

Benefit	Federal	Non-Federal public	Private	Total
Direct damages prevented.....	0	0	\$400	\$400
Increased earning power.....	0	\$110	438	548
Total.....	0	110	838	948

6. *Chalker Beach.*—(a) *Federal benefit.*—The United States does not own land in the area. Therefore, no Federal benefit will result from the improvement.

(b) *Non-Federal public benefit.*—(1) Increased earning power or value of land: The improvement will result in increased land values. Public benefit therefrom is computed as an increase in taxes on privately owned land.

Assessed value of privately owned land to be improved by direct placement of sand.....	\$38, 000
Estimated increase in land value 50 percent, or.....	19, 000
Tax rate \$22 per thousand, estimated increase in taxes.....	418

(c) *Private benefit.*—(1) Average annual direct damages prevented: The area to be improved is protected by sea walls, bulkheads, and groins. The improvement will result in a benefit computed as a saving in maintenance cost of existing protective structures.

Structure	Length (feet)	Estimated value	Estimated maintenance cost
Sea walls.....	250	\$2, 500	\$125
Timber bulkheads.....	1, 150	11, 500	1, 150
Timber groins.....	410	2, 000	200
Total estimated maintenance cost.....			1, 475

(2) Increased earning power or value of land: The improvement will result in increased value of shore land. Benefit therefrom is computed as an annual gain of 3½ percent of this increase in value.

Real value of shore land to be improved by direct placement of sand... \$95,000
 Estimated increase in value 50 percent, or... 47,500
 Annual gain at 3½ percent... 1,660

(d) Summary of benefits, Chalker Beach.—

Benefit	Federal	Non-Federal public	Private	Total
Direct damages prevented.....	0	0	\$1,475	\$1,475
Increased earning power.....	0	\$418	1,660	2,078
Total.....	0	418	3,135	3,553

7. Chapman Beach.—(a) Federal benefit.—The United States does not own land in the area. Therefore, no Federal benefit will result from the improvement.

(b) Non-Federal public benefit.—(1) Increased earning power or value of land: The improvement will result in increased land values. Public benefit therefrom is computed as an increase in taxes on privately owned land.

Assessed value of land to be improved... \$43,000
 Estimated increase in land value 25 percent, or... 10,750
 Annual tax rate \$17 per thousand, estimated increase in taxes... 182

(c) Private benefit.—(1) Average annual direct damages prevented: The area to be improved is protected by sea walls, bulkheads, and groins. The improvement will result in a benefit computed as a savings in maintenance cost of existing structures.

Structure	Length (feet)	Estimated value	Estimated maintenance cost
Sea walls.....	900	\$15,000	\$750
Timber bulkheads.....	160	1,600	100
Timber groins.....	80	500	50
Riprap and concrete groins.....	340	3,400	170
Total estimated maintenance cost.....			1,070

(2) Increased earning power or value of land: The improvement will result in increased value of shore land. Benefit therefrom is computed as an annual gain of 3½ percent of this increase in value.

Real value of land to be improved... \$86,000
 Estimated increase in value 25 percent, or... 21,500
 Annual gain at 3½ percent... 750

(d) Summary of benefits, Chapman Beach.—

Benefit	Federal	Non-Federal public	Private	Total
Direct damages prevented.....	0	0	\$1,070	\$1,070
Increased earning power.....	0	182	750	932
Total.....	0	182	1,820	2,002

8. *West Beach.*—(a) *Federal benefit.*—The United States does not own land in the area. Therefore, no Federal benefit will result from the improvement.

(b) *Non-Federal public benefit.*—(1) Average annual direct damages prevented: The parking area at the public beach is protected by a masonry sea wall, two timber and one riprap groins. The placement of fill will provide additional protection. Benefit therefrom is computed as a saving in maintenance cost of protective structures.

Structure	Estimated value	Estimated annual maintenance cost
Sea wall.....	\$20,000	\$1,000
Timber groins.....	1,000	100
Riprap groin.....	1,500	75
Total estimated savings.....		1,175

(2) Benefit from increased earning power or value of land: The improvement will result in increased value of shore land. Public benefit therefrom will be derived from increased taxes on privately owned land.

Benefit from increased taxes

Assessed value of privately owned land.....	\$17,500
Estimated increase in assessed value, 25 percent.....	4,375
Tax rate \$17 per thousand, estimated increase in taxes.....	75

(3) Recreational benefit: The improvement will result in enlarging the beach area available for recreational use. Since the existing beach has sufficient area to accommodate all bathers now using or anticipated to use the beach, no recreational benefits have been computed.

(c) *Private benefit.*—(1) Average annual direct damages prevented: Cottages in the area are located in close proximity to the shore and are subject to storm damage. The proposed fill will protect these cottages. Based on the damage which occurred during the severe storm of November 1950 and a probable recurrence once in 6 years, the benefit from this protection is estimated as \$1,000 per year.

(2) Benefit from increased earning power or value of land: Placement of sand fill will restore past losses and increase the area of shore front land. Benefit therefrom is computed as an annual gain of 3½ percent on the increase in land value.

Real value of privately owned land.....	29,000
Estimated increase in value, 25 percent or.....	7,250
Annual benefit at 3½ percent.....	250

(d) *Summary of benefits, West Beach.*—

Benefit	Federal	Non-Federal public	Private	Total
Direct damages prevented.....	0	\$1,175	\$1,000	\$2,175
Increased earning power.....	0	75	250	325
Total.....	0	1,250	1,250	2,500

9. *Grove Beach.*—(a) *Federal benefit.*—The United States does not own land in the area. Therefore, no Federal benefit will result from the improvement.

(b) *Non-Federal public benefit.*—(1) Increased earning power or value of land: The improvement will result in an increased value of shore land. Public benefit therefrom will be derived from increased taxes on privately owned land.

Assessed value of privately owned land..... \$18,800
Estimated increase in value, 25 percent, or..... 4,700
Annual tax rate \$17 per thousand, increase in tax income..... 80

(c) *Private benefit.*—(1) Average annual direct damages prevented: The shore is protected by sea walls and groins. The improvement will provide additional protection. Benefit therefrom is computed as a savings in maintenance cost of existing structures.

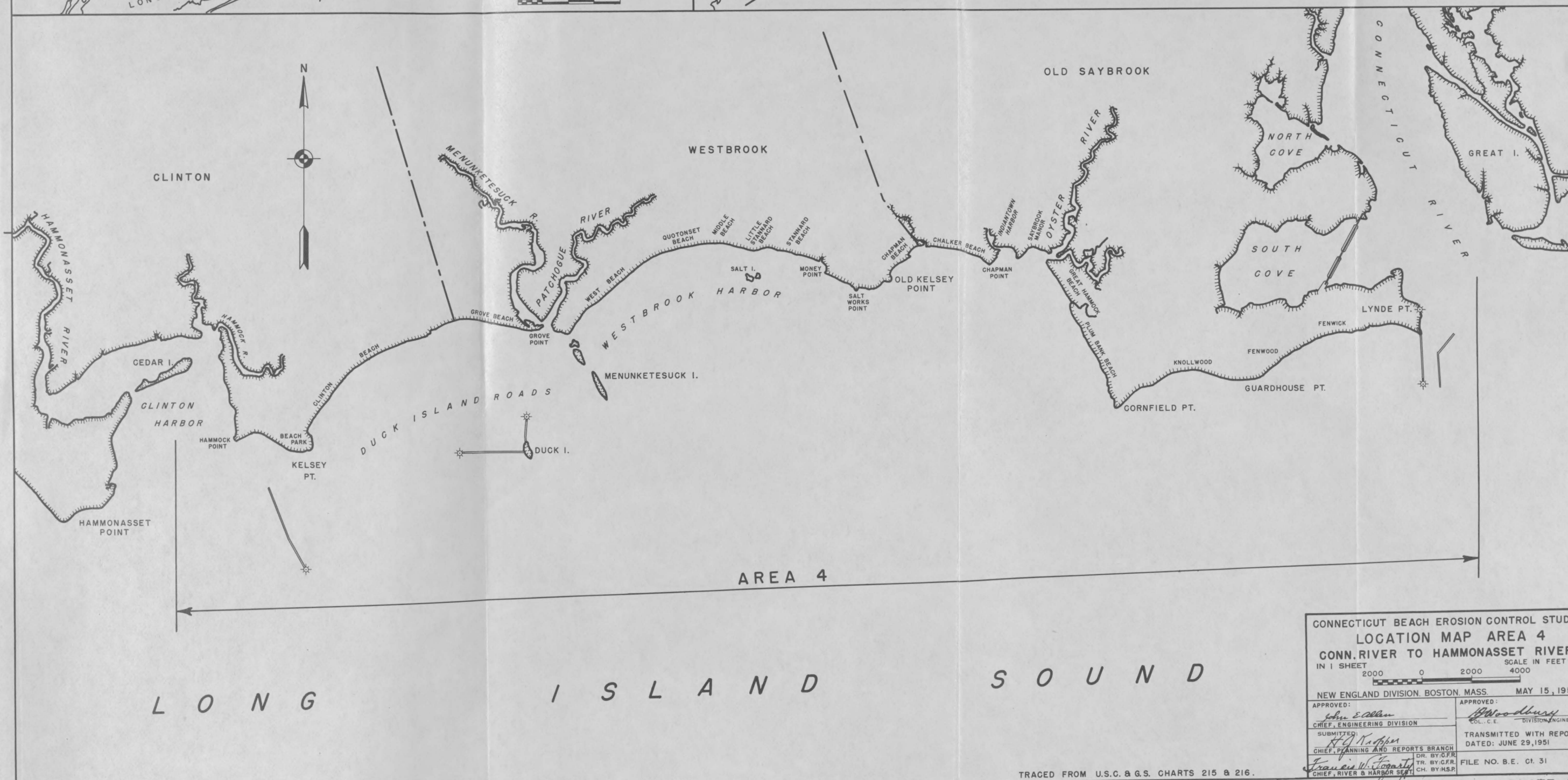
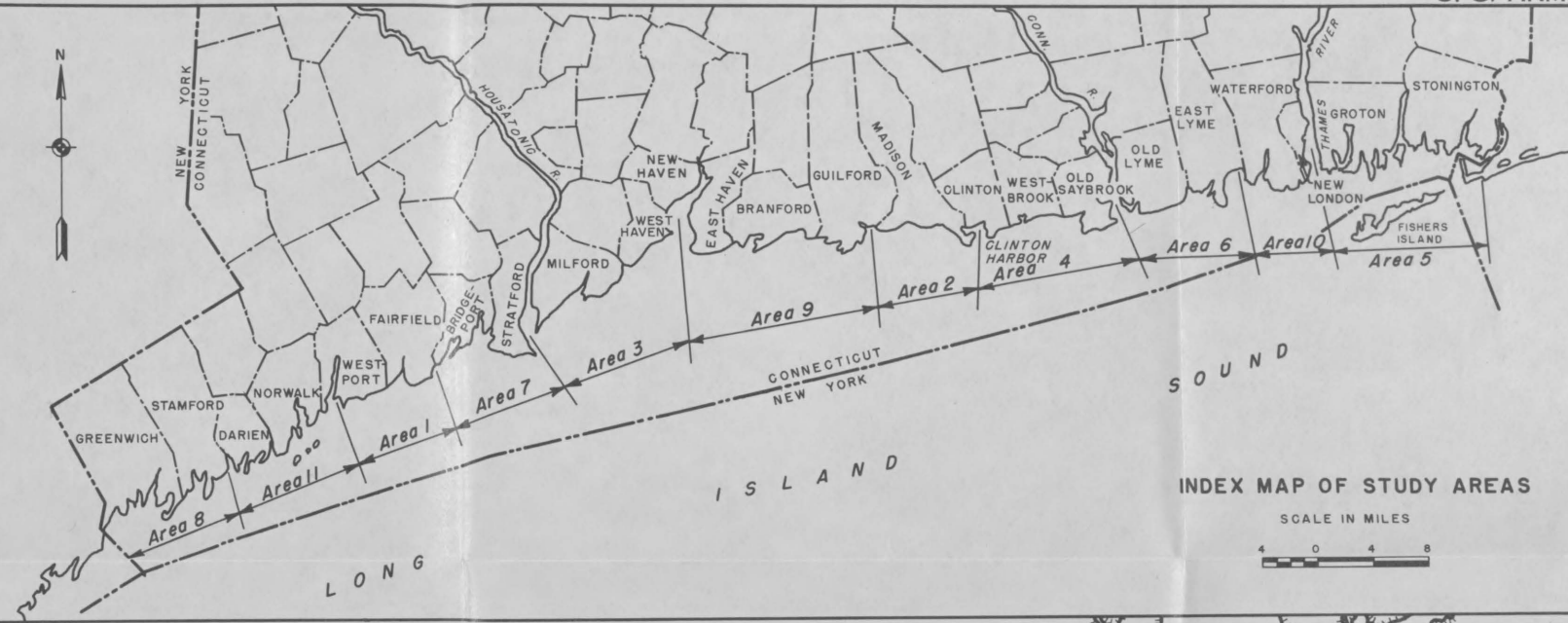
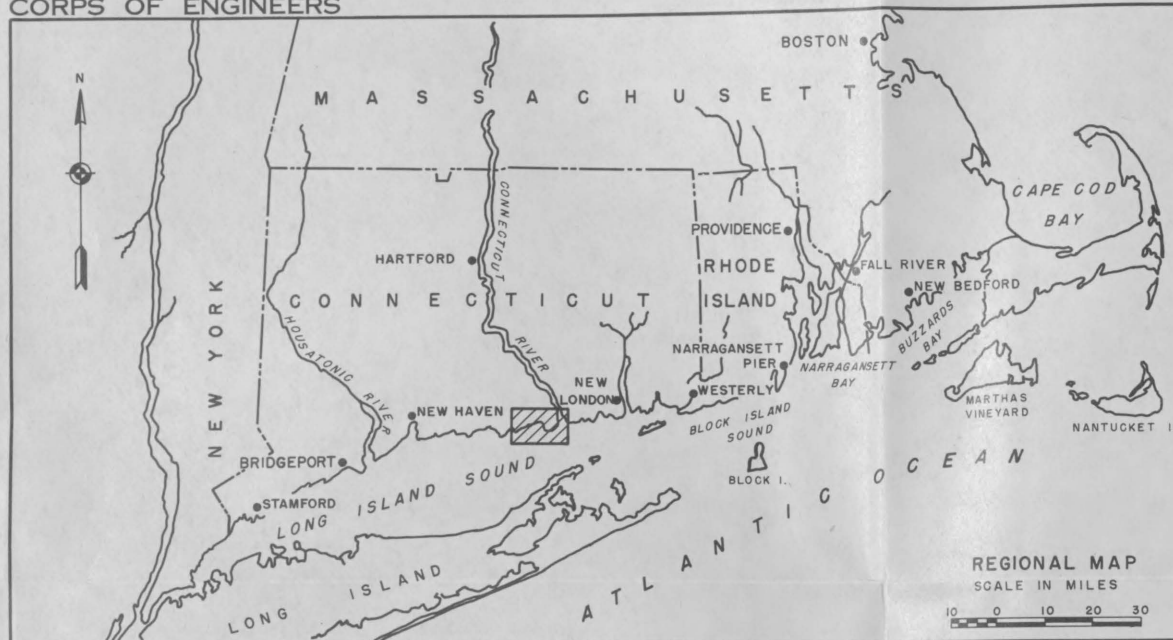
Structure	Length (feet)	Estimated value	Estimated annual maintenance cost
Sea walls.....	550	\$13,500	\$675
Timber groins.....	450	2,500	250
Riprap groins.....	30	300	15
Total estimated savings.....			940

(2) Increased earning power or value of land: The improvement will result in increased value of shore land. Benefit therefrom is computed as an annual gain of $3\frac{1}{2}$ percent of the increase in value.

Real value of land to be improved..... \$37,600
Estimated increase in value 25 percent, or..... 9,400
Annual gain at $3\frac{1}{2}$ percent..... 330

(d) *Summary of benefits, Grove Beach.*—

Benefit	Federal	Non-Federal public	Private	Total
Direct damage prevented.....	0	0	\$940	\$940
Increased earning power.....	0	\$80	330	410
Total.....	0	80	1,270	1,350



CONNECTICUT BEACH EROSION CONTROL STUDY LOCATION MAP AREA 4 CONN. RIVER TO HAMMONASSET RIVER IN 1 SHEET	
SCALE IN FEET 2000 0 2000 4000	
NEW ENGLAND DIVISION, BOSTON, MASS. MAY 15, 1951	
APPROVED: John E. Allen CHIEF, ENGINEERING DIVISION	APPROVED: B. Woodbury COL. C.E. DIVISION ENGINEER
SUBMITTED: R. J. Kappan CHIEF, PLANNING AND REPORTS BRANCH	
TRANSMITTED WITH REPORT DATED: JUNE 29, 1951	
FILE NO. B.E. CI. 31	

TRACED FROM U.S.C. & G.S. CHARTS 215 & 216.

PLATE I

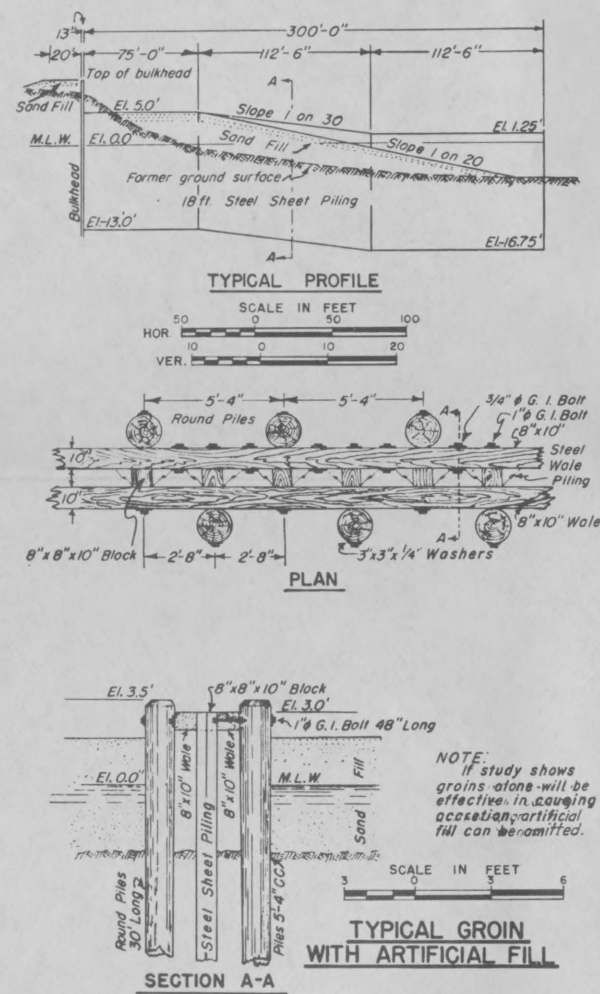


FIGURE 1

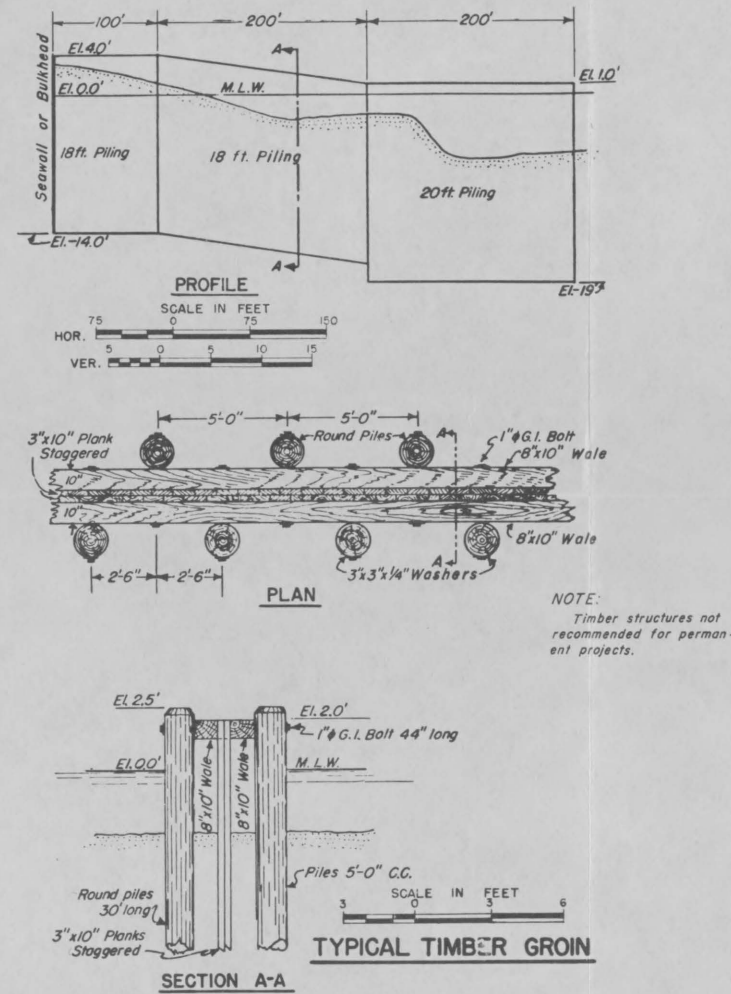


FIGURE 2

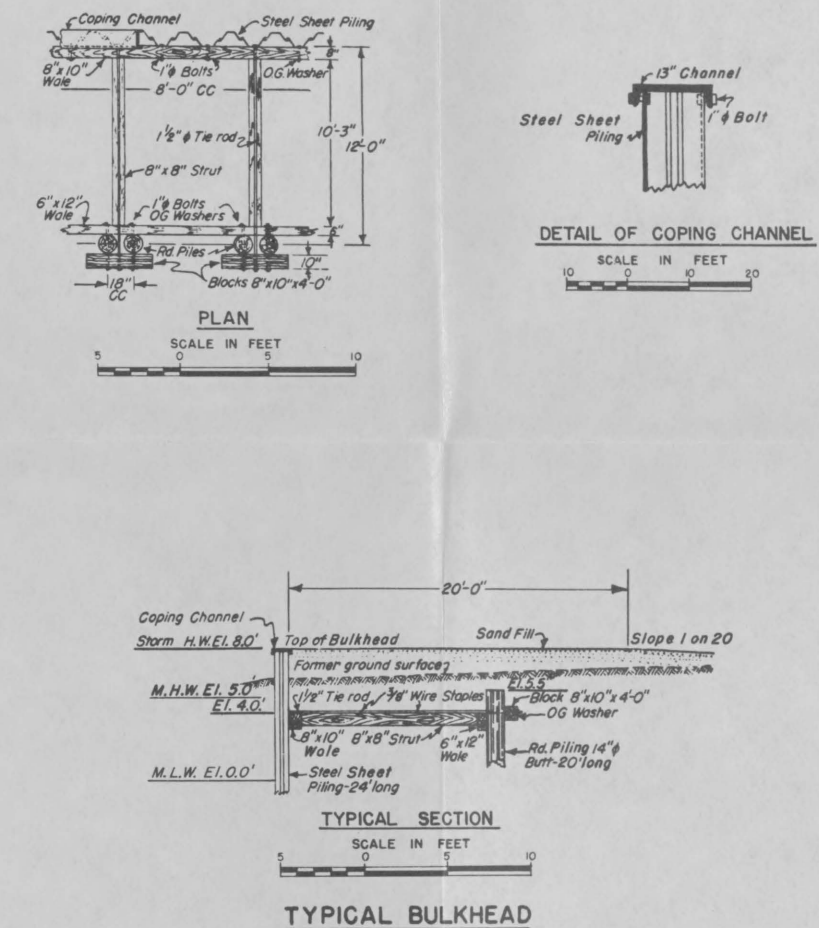


FIGURE 3

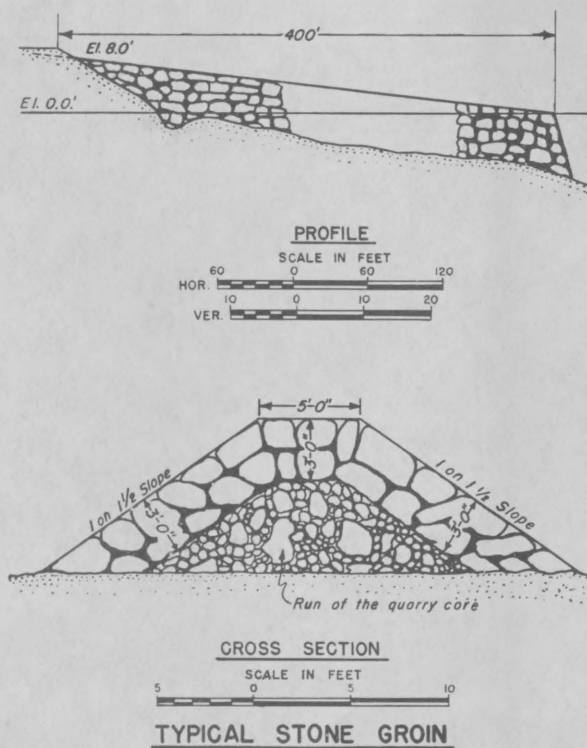


FIGURE 4

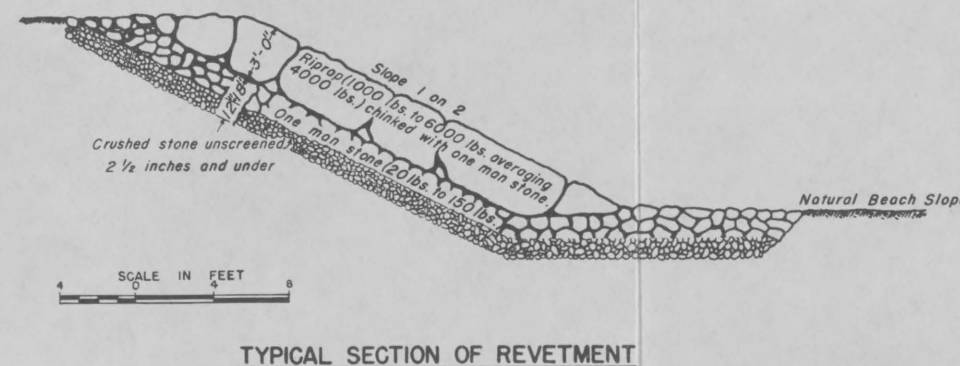
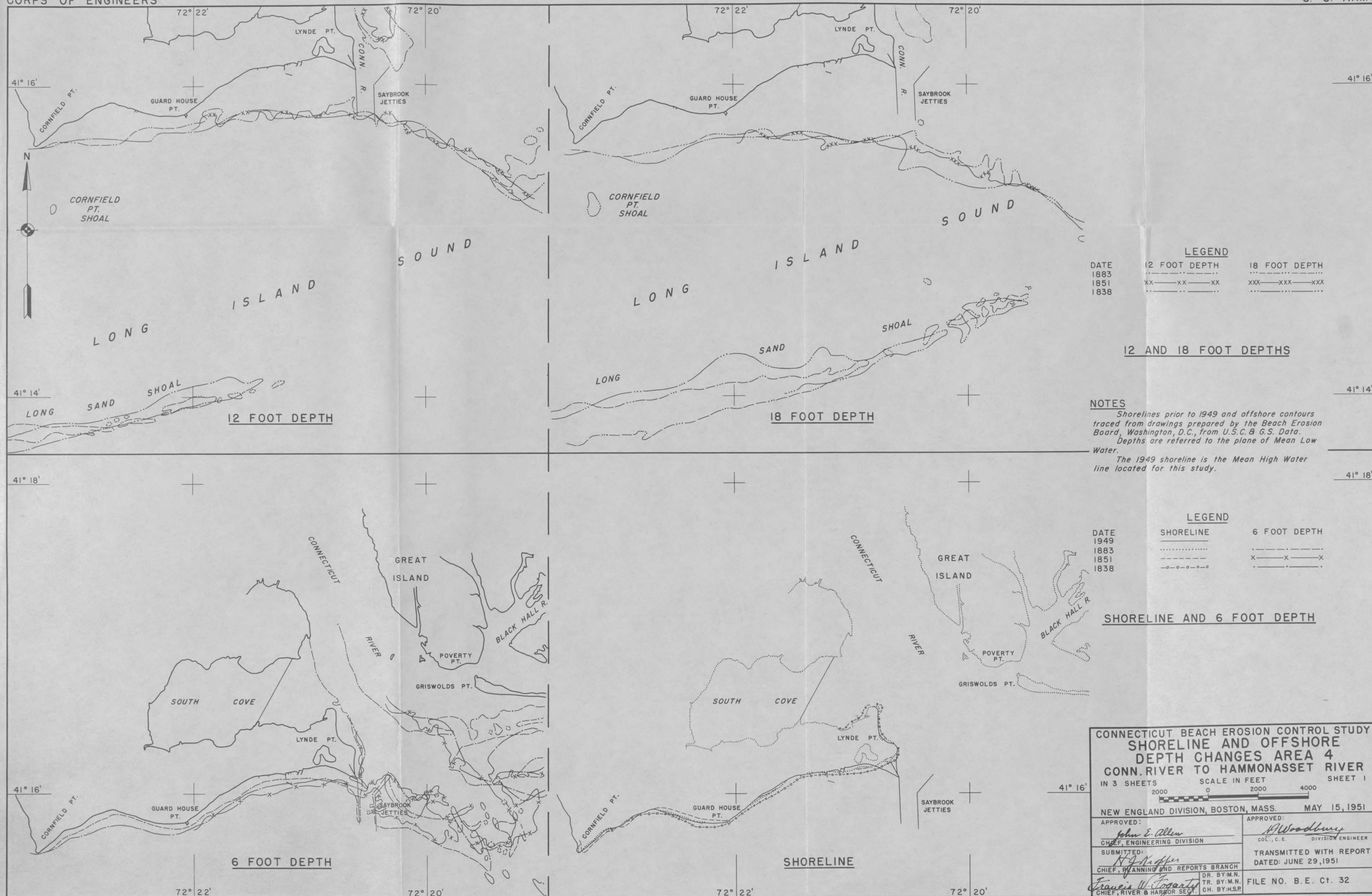
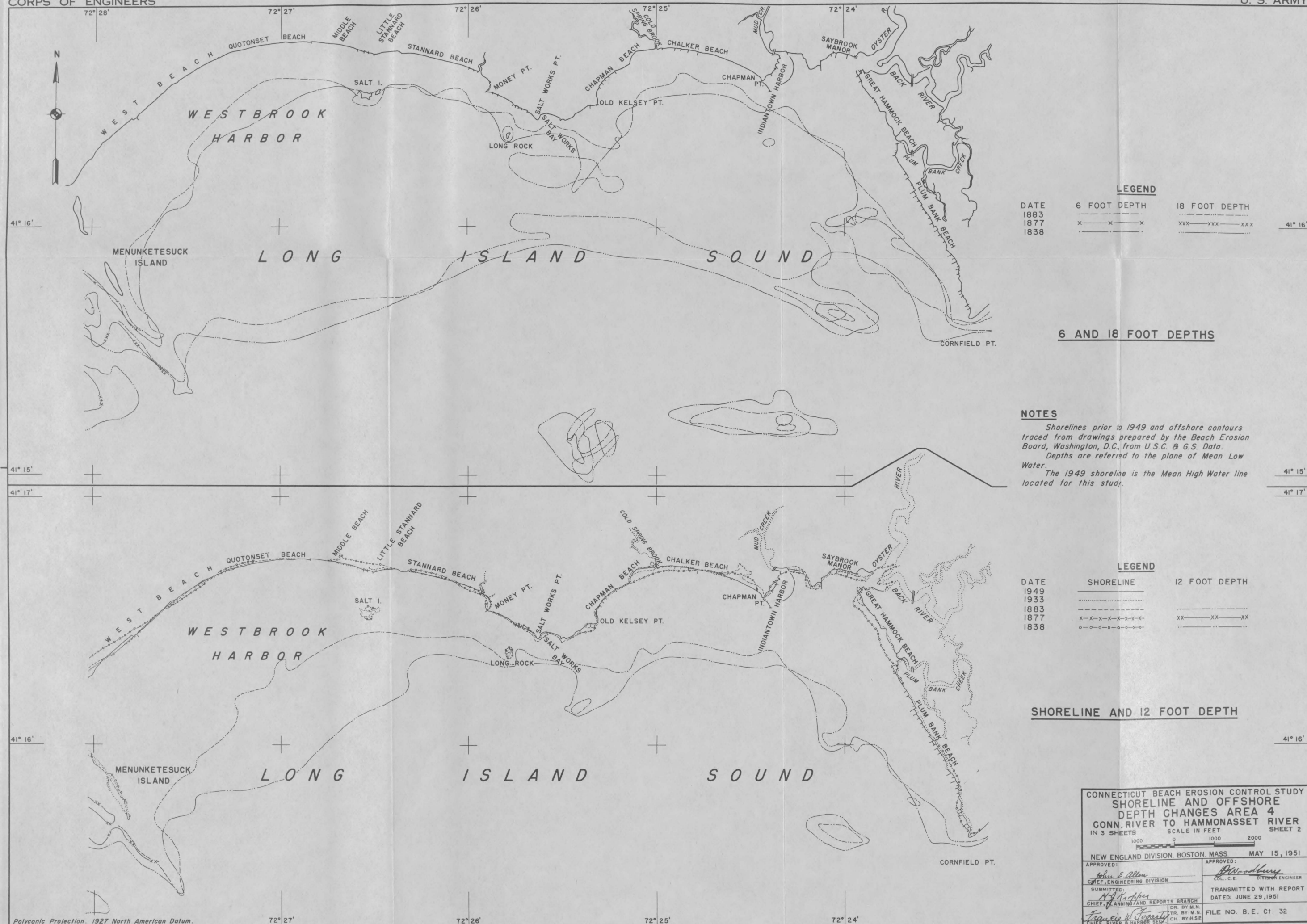


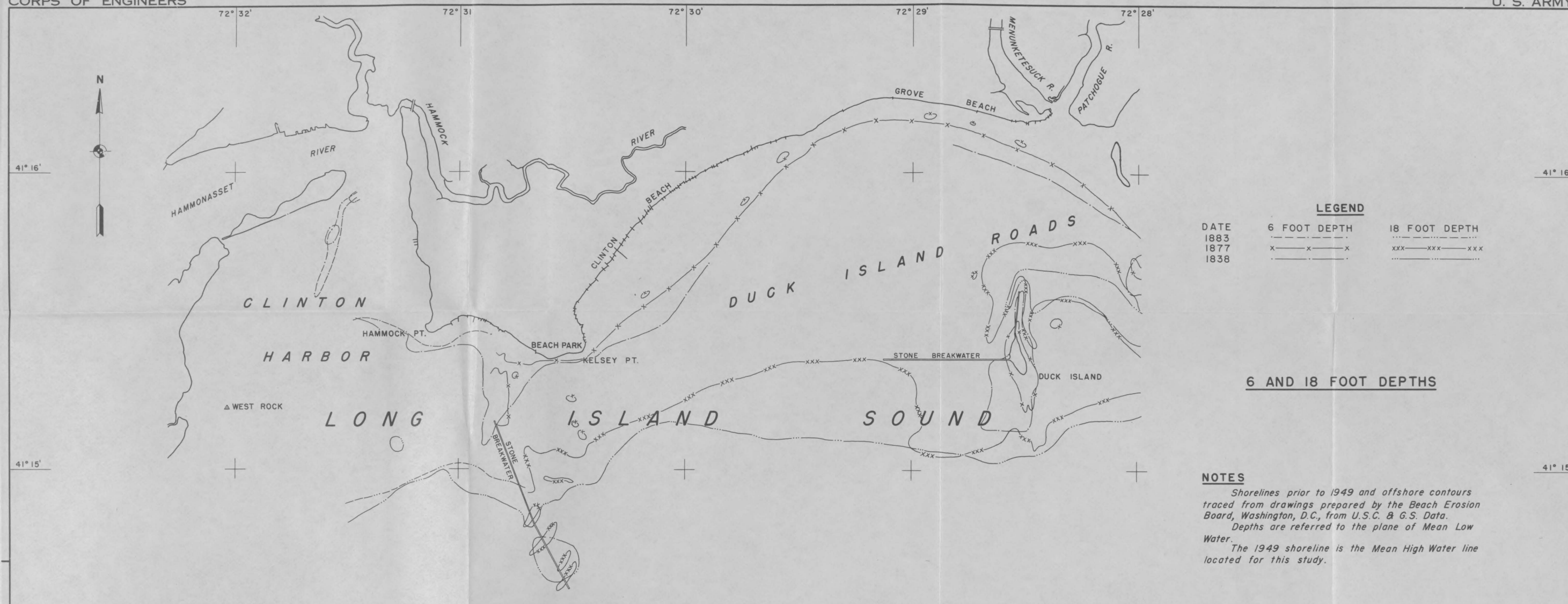
FIGURE 5

NOTE
Typical construction details reproduced from "Engineering Manual for Civil Works, Beach Erosion Studies," Part CXXXIII dated April 1947.

CONNECTICUT BEACH EROSION CONTROL STUDY	
SHORE STRUCTURES	
TYPICAL CONSTRUCTION DETAILS	
IN 1 SHEET SCALE AS SHOWN	
NEW ENGLAND DIVISION BOSTON, MASS. JAN. 20, 1949	
APPROVAL RECOMMENDED CHIEF, R. & H. OPERATIONS DIVISION SUBMITTED R & H PROJECTS AND REPORTS BRANCH	APPROVED L. T. COL. C. E., ASST. DIVISION ENGINEER TRANSMITTED WITH REPORT DATED: JUNE 29, 1951 FILE NO. B.E.CI. 6





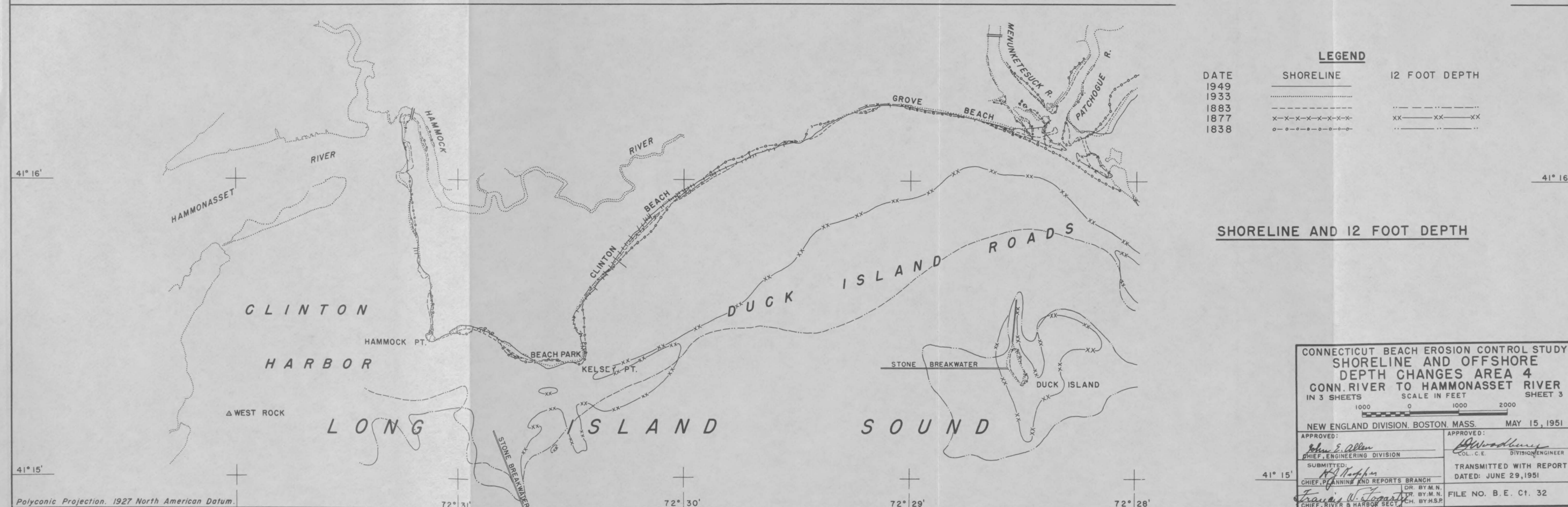


DATE	6 FOOT DEPTH	18 FOOT DEPTH
1883
1877	x-x-x-x-x	xxx-xxx-xxx
1838

6 AND 18 FOOT DEPTHS

NOTES

Shorelines prior to 1949 and offshore contours traced from drawings prepared by the Beach Erosion Board, Washington, D.C., from U.S.C. & G.S. Data.
 Depths are referred to the plane of Mean Low Water.
 The 1949 shoreline is the Mean High Water line located for this study.



DATE	SHORELINE	12 FOOT DEPTH
1949
1933
1883	x-x-x-x-x	xx-xx-xx
1877
1838

SHORELINE AND 12 FOOT DEPTH

CONNECTICUT BEACH EROSION CONTROL STUDY SHORELINE AND OFFSHORE DEPTH CHANGES AREA 4 CONN. RIVER TO HAMMONASSET RIVER IN 3 SHEETS SCALE IN FEET SHEET 3 1000 0 1000 2000	
NEW ENGLAND DIVISION, BOSTON, MASS. MAY 15, 1951	
APPROVED: <i>John E. Allen</i> CHIEF, ENGINEERING DIVISION	APPROVED: <i>Woodbury</i> COL. C. E. DIVISION ENGINEER
SUBMITTED: <i>W. J. Hoffman</i> CHIEF, PLANNING AND REPORTS BRANCH	TRANSMITTED WITH REPORT DATED: JUNE 29, 1951
CH. BY M.N. CH. BY H.S.P.	FILE NO. B. E. C1. 32

PLATE 9



LIST OF PROBINGS

NUMBER	DEPTH OF WATER	TOTAL DEPTH	MATERIAL AS INDICATED BY PROBINGS.
P1	8.3	15.2	1.0' Mud, 5.9'sand
P2	8.5	17.0	1.0' Mud, 1.1'sand, 1.0'hardpan, 5.4'sand
P3	10.4	17.6	1.0' Mud, 6.2'sand

NOTE: Probing are in feet and tenths, and are referred to the plane of Mean Low Water.

Probing were made by hand during March and April 1949.

BEACH SAMPLE ANALYSIS

PROFILE NUMBER	GRAIN SIZE IN MILLIMETER		CHARACTER OF MATERIAL IN PERCENT			
	RANGE	MEDIAN DIAMETER	FINE SAND	MED. SAND	COARSE SAND	GRAVEL
1	0.295-26.7	1.10	0	13	48	39
3	0.074-26.7	8.80	1	8	20	71
4	0.074-39.5	11.00	3	7	7	83
5	0.074-26.7	1.50	1	8	49	42
7	0.10-1.18	0.19	66	33	1	0

All samples taken at Mid Tide Elevation.

LEGEND

PROBINGS -----●P3
PROFILE NUMBERS-----③

NOTES

Soundings are in feet and tenths and are referred to the plane of Mean Low Water.

Shoreline is Mean High Water. Land contours are referred to the plane of Mean High Water. The mean tidal range is 3.5 feet.

Hydrography, shoreline and shore structures determined by 1949 survey. Other topography and contours from U.S.C. & G.S. Chart No. 215.

Plane coordinates are on the Lambert Grid System for the State of Connecticut.

CONNECTICUT BEACH EROSION CONTROL STUDY	
SURVEY MAP FOR AREA 4	
CONN. RIVER TO HAMMONASSET RIVER	
IN 4 SHEETS	SHEET 1
SCALE IN FEET 0 500 1000	
NEW ENGLAND DIVISION, BOSTON, MASS. MAY 15, 1951	
APPROVED: John E. Allen CHIEF, ENGINEERING DIVISION	APPROVED: H. Woodbury COL. C.E. DIVISION ENGINEER
SUBMITTED: H. Woodbury CHIEF, PLANNING AND REPORTS BRANCH	TRANSMITTED WITH REPORT DATED: JUNE 29, 1951
DR. BY RBT TH. BY CMA CH. BY 240	FILE NO. B.E. CI. 34



BEACH SAMPLE ANALYSIS						
PROFILE NUMBER	GRAIN SIZE IN MILLIMETER		CHARACTER OF MATERIAL IN PERCENT			
	RANGE	MEDIAN DIAMETER	FINE SAND	MED. SAND	COARSE SAND	GRAVEL
8	0.10 - 0.42	0.23	34	66	0	0
9	0.10 - 9.40	0.25	25	72	2	1
10	0.74 - 4.73	0.32	14	76	8	2
12	0.74 - 4.73	0.25	29	66	3	2
13	0.148 - 4.73	0.59	6	44	48	2
14	0.148 - 9.40	1.08	1	19	55	25
15	0.148 - 26.7	0.47	1	56	26	17
16	0.74 - 19.0	4.10	2	5	21	72
17	0.148 - 9.4	1.50	1	6	53	40
18	0.148 - 26.7	4.00	2	6	24	68
19	0.29 - 9.40	1.44	0	17	48	35

All samples taken at Mid Tide Elevation.

LIST OF PROBINGS			
NUMBER	DEPTH OF WATER	TOTAL DEPTH	MATERIAL AS INDICATED BY PROBINGS
P4	8.5	16.7	8.2' Sand.
P5	8.5	16.0	1.0' Mud, 6.5' sand.
P6	10.5	16.8	6.3' Sand

NOTE: Probings are in feet and tenths, and are referred to the plane of Mean Low Water.
Probings were made by hand during March and April 1949.

LEGEND

PROBINGS ———— P5
PROFILE NUMBERS ———— 7

NOTES

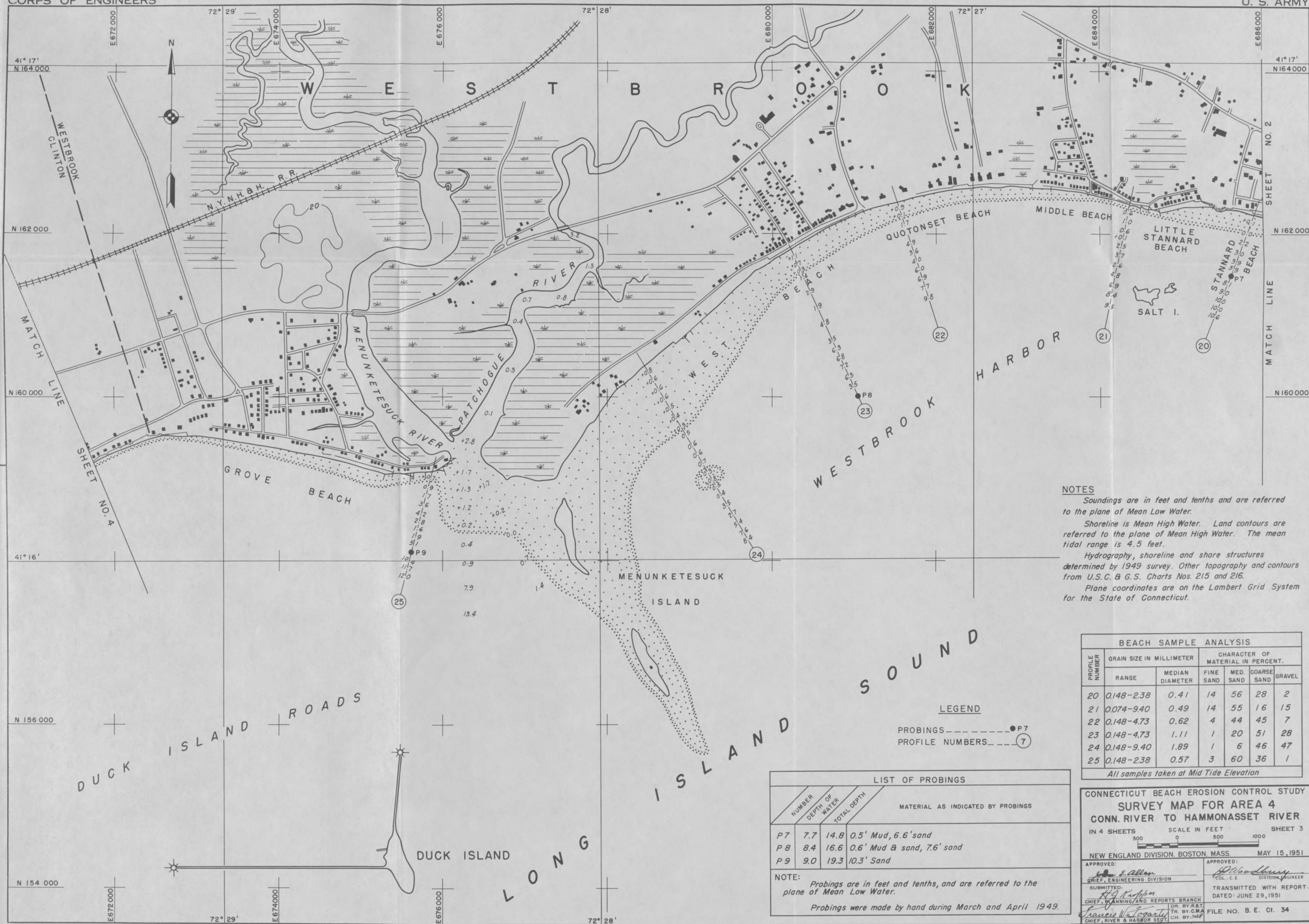
Soundings are in feet and tenths and are referred to the plane of Mean Low Water.

Shoreline is Mean High Water. Land contours are referred to the plane of Mean High Water. The mean tidal range is 4.0 feet.

Hydrography, shoreline and shore structures determined by 1949 survey. Other topography and contours from U.S.C. & G.S. Charts Nos. 215 and 216.

Plane coordinates are on the Lambert Grid System for the State of Connecticut.

CONNECTICUT BEACH EROSION CONTROL STUDY	
SURVEY MAP FOR AREA 4	
CONN. RIVER TO HAMMONASSET RIVER	
IN 4 SHEETS	SHEET 2
SCALE IN FEET 500 0 500 1000	
NEW ENGLAND DIVISION, BOSTON, MASS. MAY 15, 1951	
APPROVED: John E. Allen CHIEF, ENGINEERING DIVISION	APPROVED: J. Woodbury DIVISION ENGINEER
SUBMITTED: R. E. O'Brien CHIEF, PLANNING AND REPORTS BRANCH	TRANSMITTED WITH REPORT DATED: JUNE 29, 1951
DR. BY: RBT TH. BY: GBA CH. BY: JWP	FILE NO. B.E. Ct. 34



NOTES

Soundings are in feet and tenths and are referred to the plane of Mean Low Water.

Shoreline is Mean High Water. Land contours are referred to the plane of Mean High Water. The mean tidal range is 4.5 feet.

Hydrography, shoreline and shore structures determined by 1949 survey. Other topography and contours from U.S.C. & G.S. Charts Nos. 215 and 216.

Plane coordinates are on the Lambert Grid System for the State of Connecticut.

BEACH SAMPLE ANALYSIS

PROFILE NUMBER	GRAIN SIZE IN MILLIMETER		CHARACTER OF MATERIAL IN PERCENT.			
	RANGE	MEDIAN DIAMETER	FINE SAND	MED. SAND	COARSE SAND	GRAVEL
20	0.148-2.38	0.41	14	56	28	2
21	0.074-9.40	0.49	14	55	16	15
22	0.148-4.73	0.62	4	44	45	7
23	0.148-4.73	1.11	1	20	51	28
24	0.148-9.40	1.89	1	6	46	47
25	0.148-2.38	0.57	3	60	36	1

All samples taken at Mid Tide Elevation

LEGEND

PROBINGS-----● P7
PROFILE NUMBERS-----⑦

LIST OF PROBINGS

NUMBER	DEPTH OF WATER	TOTAL DEPTH	MATERIAL AS INDICATED BY PROBINGS
P7	7.7	14.8	0.5' Mud, 6.6' sand
P8	8.4	16.6	0.6' Mud & sand, 7.6' sand
P9	9.0	19.3	10.3' Sand

NOTE:

Probings are in feet and tenths, and are referred to the plane of Mean Low Water.

Probings were made by hand during March and April 1949.

CONNECTICUT BEACH EROSION CONTROL STUDY
SURVEY MAP FOR AREA 4
CONN. RIVER TO HAMMONASSET RIVER

IN 4 SHEETS SCALE IN FEET SHEET 3

500 0 500 1000

NEW ENGLAND DIVISION, BOSTON, MASS. MAY 15, 1951

APPROVED: *E. Allen* CHIEF, ENGINEERING DIVISION

APPROVED: *W. Woodbury* COL. C. E. DIVISION ENGINEER

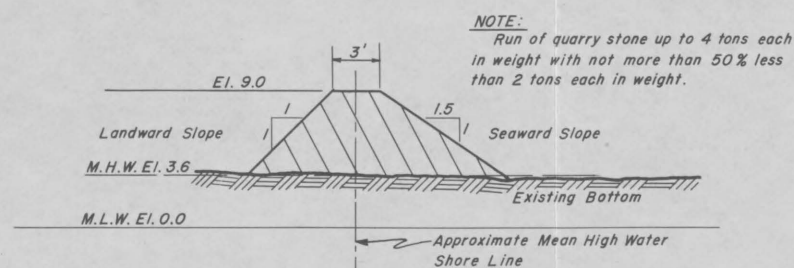
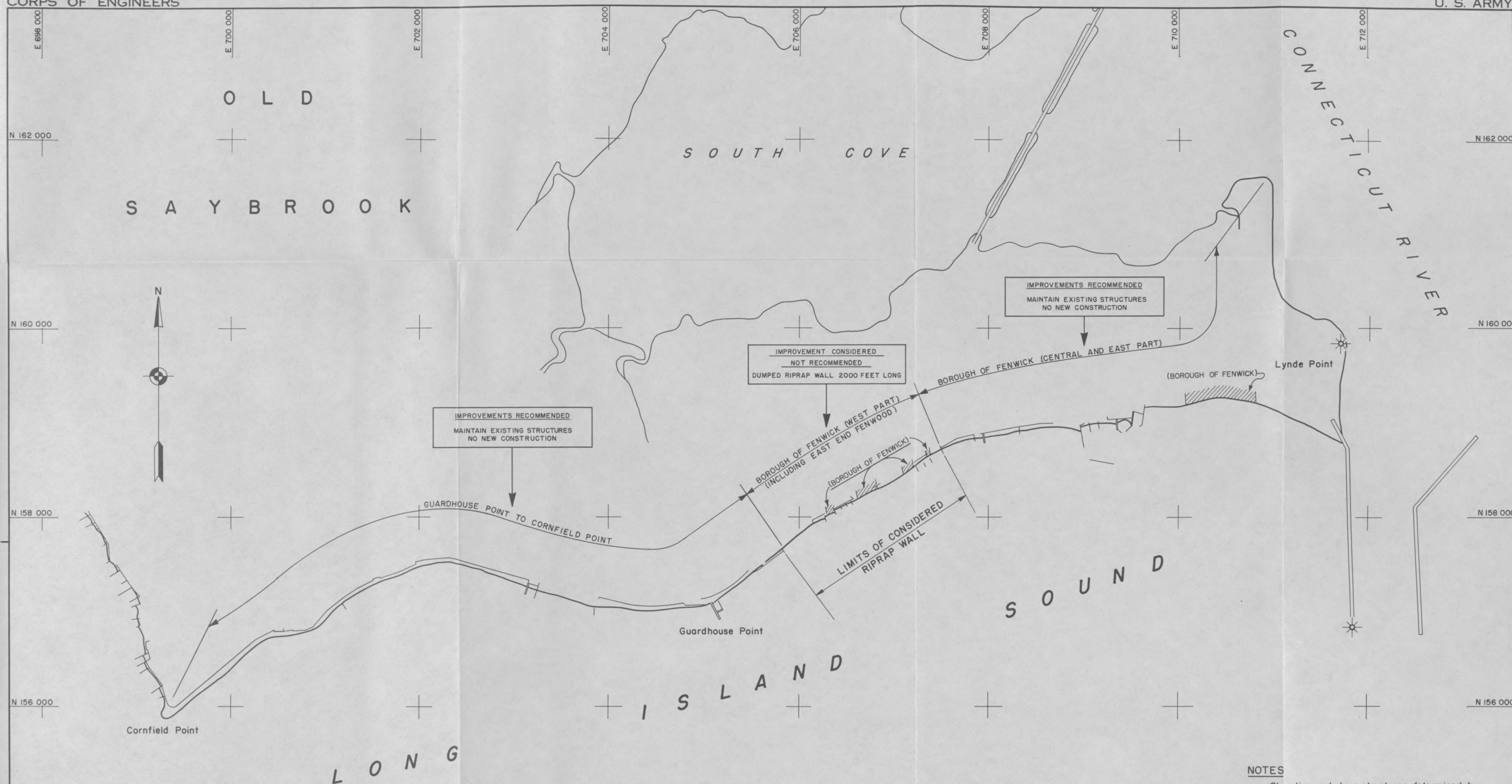
SUBMITTED: *W. Woodbury* TRANSMITTED WITH REPORT. DATED: JUNE 29, 1951

CHIEF, PLANNING AND REPORTS BRANCH

DR. BY R.B.T. TH. BY C.M.A. CH. BY J.M.P.

CHIEF, RIVER & HARBOR SECT. FILE NO. B. E. CI. 34





TYPICAL SECTION OF CONSIDERED DUMPED RIPRAP WALL
BOROUGH OF FENWICK (WEST PART)

SCALE IN FEET
5 0 5 10

NOTE:
Run of quarry stone up to 4 tons each
in weight with not more than 50% less
than 2 tons each in weight.

NOTES

Shoreline and shore structures determined by
1949 survey.
Coordinates are on the Lambert Grid System for
the State of Connecticut.
For additional construction details for shore
structures see Plate 6.
Publicly owned portions of shore shown thus:

CONNECTICUT BEACH EROSION CONTROL STUDY
PLANS OF IMPROVEMENT AREA 4
CONN. RIVER TO HAMMONASSET RIVER
IN 4 SHEETS SCALE IN FEET SHEET 1

NEW ENGLAND DIVISION, BOSTON, MASS. MAY 15, 1951

APPROVED: <i>Robert S. Allen</i> CHIEF, ENGINEERING DIVISION	APPROVED: <i>W. Woodbury</i> COL., C. E., DIVISION ENGINEER
SUBMITTED: <i>A. J. Hadden</i> CHIEF, PLANNING AND REPORTS BRANCH	TRANSMITTED WITH REPORT DATED: JUNE 29, 1951
<i>Francis W. Foster</i> CHIEF, RIVER & HARBOR SECT.	FILE NO. B. E. Ct. 35



